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ABSTRACT

A study examined the pilot year of the Computers in Early Literacy (CIEL) program, a multi-year project aimed at developing and assessing various strategies for improving the literacy development of children in kindergarten and the first grade. Subjects, 25 kindergarten and 22 first-grade students in a midwestern primary school, received three personal computers for each of two classrooms. The kindergarten class used a graphics software program and a word processor, while the first grade class used only the word processor on their three computers. Data included ethnographic observations, children's written products, and systematic student assessments. The children quickly mastered the basics of the software but had problems with the "save," "load," and editing functions of the word processor. Kindergarten children: exhibited a variety of patterns of use and forms of writing; used writing patterns at the computer similar to those observed with paper and pencil; appeared to pronounce letter names more often at the computer than when composing hand-written text; enjoyed using the graphics program to insert ready-made pictures into their stories; and collaborated at the computer. First grade students: were uncomfortable with text "jumping" or moving on the screen; provided each other with some of the needed technical support; viewed, by the end of the year, the computer as just another tool similar to the pencil and crayon to be selected when appropriate; used the computer in widely different ways. (Numerous examples of students' writing, five tables of data, and two figures representing the classroom arrangement are included.) (RS)

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The Use of the Computer as a Writing Tool in a Kindergarten and First Grade Classroom

CIEL Pilot Year Final Report, Part 2

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CIEL Project Directors
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Submitted to the
Office of the Vice President for Research
The University of Michigan
and
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The CIEL project is indebted to many people and organizations. At a difficult time for project funding, Linda Wilson—Vice President for Research at The University of Michigan—provided bridging funds which made the Pilot Year possible. Apple Computer (the Southeast Michigan regional office and the corporate office in Cupertino) provided the hardware. Numerous software vendors provided copies of their programs for use in the project.

Martha Spencer was the technical coordinator for the classroom computers. Her expertise and constant attention to detail kept the computers running and the students happy. She developed and implemented the training program to teach students how to use the software. Her work is summarized here and detailed in her own report which appears in the appendix.

The kindergarten and first grade teacher were central to the entire project. Their cooperation was essential and their assistance invaluable. But more important, their deep understanding of children and their educational needs played a critical role in shaping our understanding of the best uses of computers in the classroom.

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INTRODUCTION

CIEL—Computers in Early Literacy—is a multi-year project aimed at developing and assessing various strategies for improving the literacy development of children in kindergarten and first grade. In the 1988-89 school year, with funding from the University of Michigan's Office of the Vice President for Research and equipment from Apple Computer, a pilot test was conducted of important aspects of the CIEL approach and of the research strategies used to assess them. This part of the report on the pilot year focuses on the potential of the computer to contribute to the literacy development of children in kindergarten and first grade.

The CIEL project has involved several distinct research strands, including literacy development of children in a variety of contexts and the role of teaching strategies and computer technology in promoting its development. This report addresses the computer component of the larger CIEL research agenda. This component consists of a series of observational studies and assessments designed to examine the use of the computer as a multifaceted literacy tool within an emergent literacy framework. The two broad issues we have addressed in our 1988-89 studies, and report on here, are: (1) how young children use the computer as a writing tool, and (2) how the computer gets incorporated by teachers into the literacy environment of a kindergarten and a first grade classroom. These issues reflect different levels of interest—a developmentally oriented focus on the individual child, and a pedagogically oriented focus upon the teacher and the classroom—each of which is critical to understanding the use of computers within early literacy instruction.

A number of questions have been addressed with regard to the use of the computer as a writing tool. An important focus has been the description of how children write and reread from their own writing at the computer. What patterns emerge as children write using a graphics program (which supports scribble and drawing) and a word-processor (which supports text forms of writing)? How does the writing process at the computer differ from writing with pencil/crayon and paper? In what ways do the various functions within the graphics program or word processor help or hinder the compositional process? What is the child's level of mastery and conceptual understanding with regard to these different functions (e.g., cut and paste, delete, save, load)? What new strategies do children devise in response to the unique features and capabilities presented by the software? What are children's attitudes towards writing at the computer?

Within the context of examining these questions another focus of study emerged. As we observed children working collaboratively, we began to examine the nature of collaboration that occurs as children write together at the computer. How do the production tasks vary when children write together instead of alone? How do children negotiate the different roles and tasks involved in the writing process within a computer context? Are there particular characteristics unique to the computer writing environment that seem to facilitate collaboration?

In addition to children's individual and collaborative use of the computer as a literacy tool, we were interested in documenting the overall process of integrating the computer into the daily life of the classroom. From past research, as well as our own experience in the classroom, we know that the full integration of the computer into the ongoing routines and perceptions that shape the realities of the classroom is a gradual process. In many classrooms across the country, the computer is relegated to the role of an electronic workbook, administering drill and practice programs that focus upon discrete reading and writing skills (e.g., letter recognition, letter-sound relationships, word recognition, spelling). Our vision of the computer as a multifaceted literacy tool pushes against the notion of the computer as a narrowly focused, stand-alone device. Not surprisingly, this approach requires a much greater level of involvement on the part of the teacher. If the computer is to play a more central and holistic role in literacy instruction, the teacher must orchestrate the use of the computer with other components of the literacy program. For this reason, how the teachers viewed and managed the computers in the first year of implementation was of particular interest to us.

A number of questions were addressed in the context of documenting the teacher's evolving conceptions with regard to the role of the computer as a literacy tool. How do the teacher's ideas about and attitudes towards the computer change in response to her classroom observations and experiences? What are the teacher's perceptions and concerns with regard to specific pieces of software? What types of instructional routines and procedures are introduced and/or adapted by the teacher to accommodate and facilitate the use of computers? Another practical issue concerns the amount of instructional and technical support required in order to keep the hardware and software operating smoothly.

In this, the first year of the project, these questions were explored in a single kindergarten and first-grade classroom. There were twenty-five kindergartners and twenty-two first graders (this does not include children who left the classroom prior to the end of the year). The classrooms were located in a single K-3 school in a medium-sized midwestern city (population 150,000). The school drew from several attendance areas as a result of an integration plan. The areas included several low-cost housing projects as well as middle-class neighborhoods. Although predominantly white, the classes were mixed racially—black, white, Hispanic, Oriental. Economically the range was wide; approximately 20% qualified for the free lunch program, and a number of parents were highly-educated professionals. The teachers were both experienced, recognized by their colleagues and school administrators as outstanding teachers. They were selected because of this expertise, since they could best help the project staff refine the materials and procedures of the project. Each classroom had a different student teacher throughout the Fall and the Winter semesters.

The small scale of the pilot year permitted easy development and refinement of methods and procedures for implementing the computer-based literacy activities and studying their impact on literacy development. Although exploratory, the pilot year provided invaluable information about many of these questions. Our findings are described in the report that follows.

In the next section of this paper, the following topics are discussed with regard to both the kindergarten and the first grade classrooms: teacher training, support, and collaboration; software selection; computer configuration in the classrooms, and research methods. Subsequent sections report the findings of the research separately for each classroom. The topics include the literacy environment of the classroom; training students to use the computers/software; the availability and use of computers; children's writing patterns at the computer; mastery of word-processing functions; children's conceptions regarding writing at the computer; and children's attitudes towards computer writing.

GETTING STARTED

Teacher Training, Support, and Collaboration

Teacher training and support is an important component of CIEL. We began working with the teachers during the summer of 1988, providing them with resources and gaining their input on various aspects of the CIEL intervention. Research on computer use in schools makes it clear that the vast majority of teachers have not incorporated the computer into their everyday instructional activities (Johnston, 1985; Sheingold, Kane & Endreweit, 1983; Yin & White, 1984). Physical presence alone is not enough to ensure the computer's integration with the curriculum. Lack of personal exposure and inadequate preparation are two barriers to the effective implementation of the computer. At the beginning of August (three months prior to implementing computers in the classrooms) we provided each teacher with an Apple IIGS system, with printer, for use at home. Several adult-oriented applications were provided for the teacher's personal and/or professional use *(Appleworks, MultiScribe)*. In addition, a range of early literacy software was also made available for the teachers' review. This gave teachers an opportunity to familiarize themselves with the hardware to be used in the project, as well as to become actively involved in the software selection process.

Both teachers had previously taken part in workshops on emergent literacy conducted by Sulzby and had expressed their interest in extending their implementation of emergent literacy techniques. Both teachers had also worked with the IBM Writing to Read program in their school and were interested in incorporating computer applications in more integrated and holistic ways within their classrooms. Prior to the beginning of the 1988-89 school year, the CIEL research team met with the teachers to discuss their previous experience with emergent literacy and computers. It was clear during this meeting that these teachers were already carrying out many activities that were consonant with an emergent literacy approach. Their familiarity with the use of the computer as a writing tool, albeit within the context of the Writing to Read curriculum, was also viewed as an asset.

It was established at the onset that our working relationship with the teachers was viewed as a collaboration, with the CIEL team providing support for the implementation and integration of emergent literacy techniques and related computer activities, and the teachers providing suggestions and feedback regarding the design and outcomes related to these implementations. A number of steps were taken to assure ongoing communication between teachers and researchers throughout the school year. One month prior to setting up the computers within the classrooms, a teacher liaison began making weekly visits to discuss with teachers any concerns or questions they might have regarding emergent literacy activities and the upcoming computer implementation. These weekly visits continued for nearly two months after the computers had been introduced. At this point, the teacher liaison left CIEL to take a position elsewhere, and the technical assistant and the classroom observer took over the function of maintaining regular contact with the classroom teachers.

The technical assistant and classroom observer were frequently available to offer ongoing computer assistance and support, especially during the initial phases of introducing the computers in the classroom. The technical assistant worked closely with the teachers in setting up the computer centers within each of the classrooms and took responsibility for preparing the software for classroom use (e.g., setting program options, formatting student disks) and for making sure that all of the equipment was fully operational. Throughout the school year, the technical assistant kept an extensive log of activities related to hardware/software management (see the Technical Log in the

Appendix). She spent much time introducing and training individual and small groups of children on the software and was available to assist as needed for the duration of the school year. The classroom observer, who was also well versed in software/hardware issues, was available to assist in the computer area during her frequent classroom visits.

In addition to the informal contacts which took place during the course of the regular school day, a number of special meetings were conducted. The teachers were interviewed by the classroom observer on a periodic basis to clarify the issues raised in observational notes. Bi-monthly meetings were also held with the entire CIEL team. These meetings served several functions, which included: reporting on progress within the project, reviewing individual children, discussing software issues, and sharing ideas for emergent literacy activities. In the early Spring, both teachers helped plan and co-present workshops on the use of computers as writing tools for a state-wide computer conference. Their participation in this conference provided an opportunity for talking through many issues related to computer use, and served as a catalyst for generating new ideas, which were implemented in their classrooms during the remainder of the school year.

Software Selection

Each teacher took an active role in selecting software that she felt was best suited to the needs of her classroom, choosing from among a collection of highly rated software. Johnston and Olson (1988) conducted an extensive review of reading and writing software for the early grades, producing a videotape and accompanying print materials designed to provide educators with an overview of current software in this area (see the Appendix for *The Software Finder: Early Literacy K-2)*. Prior to being given a selection of software for their own review, the teachers viewed the videotape and were given a brief "hands on" demonstration of each program. The programs presented to the teachers fell into in four categories:

- A graphics program to support children composing stories through scribble and drawing.
- Several word-processors, including one that utilizes speech synthesis to "read back" what the child writes.
- A reading comprehension series.
- A small array of targeted tutorials (focusing upon letter-sound relationships, letter recognition and spelling patterns).

Before describing the software that was actually used in the classroom, it is worth first mentioning some of the considerations and concerns that were raised by the teachers in response to this initial array of choices. From an emergent literacy perspective, the ideal writing tool would allow the child to move freely across all of the emergent, as well as the conventional, forms of writing: drawing, scribble, random letter strings, and invented spelling. Currently, such a tool is not yet available for young children. A possible solution, which we proposed for both kindergarten and first grade classrooms, would be to use a word processor in combination with a graphics program. This approach was used in the kindergarten classroom, but was rejected by the first grade teacher for several reasons. She did not want to use the graphics program because, although she accepted children's use of drawing as a non-computer form of writing, she felt that the graphics components would lead children away from letter-oriented forms of writing. She was also concerned that the children would be overwhelmed or confused by the need to learn a separate set of procedures associated with a second writing tool. At the end of the school year, the first grade teacher commented that she would consider using a graphics program in the future if it supported the intricate and highly detailed kind of drawing that several of her students were able to produce with paper and pencil (the program we were looking at for the Apple IIgs did not allow for this level of resolution and control).

Both teachers had adversive reactions to the word processors that utilize speech synthesis to read back what the child has written (*Dr. Peet's Talk/Writer, Talking Text Writer*). They found the speech difficult to understand and were irritated by the mechanical quality of the "voice." Another possible reason for their resistance to these programs may have been because the speech feedback was not analogous to other literacy activities with which the teachers were already familiar. Although teachers may sometimes sound out or read back what children have written, this does not often occur on an immediate and continuous basis during composition. Both teachers expressed concerns that the students would not be able to make use of the speech feedback, and that it might disrupt or confuse the writing process.

Selected reading and writing tutorials *(Reader Rabbit, Letters and First Words, Reading Comprehension-Level One, Tiger's Tales,* and *Muppet Word Book)* were offered as programs to be used for targeted purposes, with individual children who are clearly ready for the various skills presented. At the beginning of the school year, it was clear that both teachers were somewhat overwhelmed by the choices, and were not particularly impressed by any of the activities offered in these programs. Their previous experiences with Writing to Read seemed to color their perceptions of the tutorial software. In Writing to Read a step-by-step tutorial package is presented in which all of the major instructional decisions have been built into a sequenced set of lessons by the software designers. In contrast, the software we presented seemed piecemeal and required a great deal more orchestration on the part of the teacher. Midway through the school year, the researchers made recommendations for specific pieces of software to meet the needs of individual first graders, based upon information gathered from the emergent literacy assessments. While the first-grade teacher appreciated the diagnostic input, she was more comfortable adapting existing routines to meet students' needs, rather than with bringing in additional software. She felt that personal interaction with children, in combination with the use of worksheets, was an approach which gave children the individual feedback they needed while allowing her to monitor their progress.

A few pieces of software (*Reading Comprehension, Letters and First Words*) were briefly introduced and used by a few first graders, but for the most part the tutorial software remained unused for the duration of the school year. While the kindergarten teacher was less resistant to the tutorial packages themselves, she opted not to use them. She felt that, given the limited "per student" access to the computers, a higher priority was mastering the basic graphics program/word processing functions.

Our general observation regarding the use of tutorials is that they were difficult to implement, especially during the first year of the project, for mostly pragmatic reasons. Incorporating these programs into the already established routines of experienced teachers would have required more time and energy than the teachers were able to give, given their already full workloads. While we had hoped to have the opportunity to observe children interacting with this type of software, we were comfortable with the priority placed upon open-ended writing tools, which in principle are more consonant with a developmentally-oriented approach.

Magic Slate (20 column version) was selected by the first grade teacher as the word processor for use in her classroom. It is designed for the early grades, features an iconic menu and large print, and includes a range of basic word-processing functions (e.g., automatic word-wrap, insert, delete, and choice of type styles). The teacher felt comfortable with this program largely due to her previous exposure to it through other teachers who had used it and given it high ratings. Initially this was the only program she wished to have in her classroom. Later in the school year, *Reading Comprehension* and *Letters and First Words* (see *The Software Finder* for descriptions) were introduced to a few selected children.

In the kindergarten classroom, *Color Me* and *Muppet Slate* were selected as the word processor/graphics program to be offered simultaneously (on separate computers), thus allowing for all forms of emergent writing at the computers. *Color Me* is a mouse-driven children's graphics program that offers a range of drawing options on a "point and click" menu bar and also allows for text entry via the keyboard. *Muppet Slate* is an easy to use beginning word processor that includes an option which allows children to insert ready-made pictures into their stories. *Muppet Slate* can be used with either the standard keyboard or the Muppet Learning Keys, a colorful touch pad keyboard designed for young children. In contrast to the QWERTY keyboard, letters on the Muppet Learning Keys are arranged in alphabetical order and special function keys are identified by graphically explicit icons (e.g., a "Go" sign functions as the enter key, "Zap" for escape). In addition to these two programs, the *Muppet Discovery Disk* was also used as an introductory program. The *Discovery Disk* is designed to familiarize children with the special keyboard layout and functions of the Muppet Learning Keys. One of the three featured games on the disk is a letter recognition activity in which children are presented with a letter or a picture and are asked to identify the corresponding letter.

The Computer Configuration in the Classrooms

Computers were installed in late October in the first grade classroom and in late November in the kindergarten classroom. All of the hardware used in the CIEL project was donated by Apple Computer. The Apple IIgs was selected primarily due to the fact that most of the currently available reading and writing software for the early grades has been designed for use with the Apple II series. We were also concerned about the exportability and applicability of CIEL techniques and findings to other settings, and at this time the Apple II series is the computer of choice in the majority of public schools throughout the country. Despite these compelling factors, it should be noted that this particular choice was viewed as somewhat of a compromise, as there are more sophisticated and user-friendly models, such as the Apple Macintosh, which would have been a more desirable choice if only the age-appropriate software were available.

The computer configuration in each classroom consisted of three Apple IIgs computers, each equipped with a color monitor, a 3.5 inch and a 5.25 inch disk drive. In the first grade classroom, there were two ImageWriter II printers, which eventually serviced all three computers through the use of a switch box (installed in March). The kindergarten classroom functioned with one printer (also connected to all computers via a switch box in March). A second printer was added in May. It was our original intention to link the computer systems in each classroom via a network to a single hard disk that would contain all of the needed programs and children's work files. This would have eliminated the necessity for children to load their own disks. We were unable to carry out this plan due to the fact that several key pieces of software would not operate on a network and/or could not be installed onto the hard disk.

Because we were unable to network software to a common server (i.e., a hard disk), it was necessary to create a separate data disk for each student for each of the writing programs. In the kindergarten room, 5.25 inch student disks for *Color Me* and *Muppet*

Slate were stored separately in two clearly marked storage boxes, each of which was divided into color-coded sections to aid children in locating their disks. While 3.5 inch disks would have been preferable, as they are more durable, they were not an option with the particular software used. In the first grade classroom, *Magic Slate* disks (3.5 inch format) were also stored in a color-coded storage box next to the classroom computers. In both classrooms, children had little difficulty learning the procedures for loading and ejecting their disks without assistance. Many children took obvious pride in the fact that they had their own disks, which they were able to manage independently. There was only one instance of a disk being damaged due to mishandling on the part of a child.

In the kindergarten classroom, the computers were clustered together on two long, low tables against the outside wall at the far end of the room (see the classroom chart in the "The Kindergarten Classroom" section). When seated at the computers, children faced one another, but could not see one another's computer screens. The art and science areas were located to either side of the computer center, and it was a frequent occurrence for children to stop and observe or to interact with their peers at the computers on their way to these other activities.

In the first grade-classroom, the computers were located near the classroom entrance next to the teacher's desk and the large group/book area (see the classroom chart in the "The First Grade Classroom" section). Two of the computers were arranged next to one another in a V-shaped fashion and the third computer was located on a separate desk, about ten feet from the others. The computers were arranged in such a way that the children working at them had their backs to one another; thus when looking over their shoulders, they could see other children's computer screens.

The CIEL computer implementation was designed in collaboration with each teacher, to reflect her teaching style and the literacy environment of that particular classroom. Given this approach, the ways in which the computers were introduced and used in each classroom differed. This is discussed in detail in later sections.

Research Methods

A combination of research strategies were used to study the many questions in the research project. These included systematic classroom observations as well as various student assessments. The research activities were spread out across the entire school year as shown in the table below.

1988-1989	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**April**	**May**	**June**
Computer Implementation		--								
Research Activities										
Classroom Observation	Baseline----	Teacher-elicited writing	Use of the computer as a literacy tool-----------------------							
Student Assessments		Computer pretest	Monthly Writing Samples------------------						posttest	

We approached the research task of documenting and describing the literacy activities and the implementation and use of computers from an ethnographic perspective. Our researchers became "privileged observers" (Wolcott, 1988), observing on a regular basis the interactions among teacher, children, computers, and tasks. In the classroom, observers took extensive field notes. These notes were carefully written up following a set of conventions that was devised in advance by the research team and adapted as needed (see the Observation Handbook in the Appendix). Once transcribed, the notes were synthesized and interpreted to produce a coherent, comprehensive account of what happened. Occasionally, teachers were interviewed to clarify and amplify issues that were raised in the context of the observational notes.

Classroom Observations

Classroom observations were conducted in four phases. Three sets of observations focused upon a general description of the literacy environment within the two classrooms. These observations took place at targeted points during the school year (described below). The fourth and largest set of observations focused upon the use of the computer as a writing tool. These observations began in late fall, when the computers were first introduced and continued through the school year.

Baseline observations. The first set of observations (three mornings totaling 5 hours in the kindergarten, and two mornings totaling 5.5 hours in the first grade) took place during the very first week of school. This was viewed as a critical period during which the teacher and students negotiate routines, tasks, and roles which will be in place for the school year. An important focus of these initial observations was the messages about literacy that were stated explicitly or were established implicitly by tasks, classroom arrangement, and schedules.

The second set of observations took place during the first and second weeks of October, after emergent reading and writing assessments had been completed and the classroom daily routine was more settled in. The purpose of these observations was to produce a baseline description or characterization of the participating classrooms, with a particular focus upon events and expectations regarding literacy. These observations were conducted by a single observer (three mornings totaling 8 hours in the kindergarten; two mornings and an afternoon totaling 7 hours in the first grade). A second group of observations, conducted by different observers in each of the classrooms, took place in May for the similar purpose of describing the overall literacy environment within each classroom.

Teacher-elicited writing. A third set of observations consisted of descriptions of teacher elicited group writing (three observations in each classroom). The purpose of these observations was to document each teacher's particular approach to eliciting and responding to children's writing in the classroom, with a particular focus upon the language used and the messages given regarding various forms of writing and rereading. These observations took place both before and after computers had been introduced.

Student computer use. The final, and the most extensive, set of observations were conducted on a systematic basis from the time the computers were introduced into the classrooms through the remainder of the school year (twenty nine observations totaling 20 hours in the kindergarten; twenty three observations totaling 17.5 hours in the first grade). These observations focused upon children's use of the computer as a writing tool. Children were observed, individually and in pairs, during regularly occurring classroom writing periods. In addition to documenting the writing process as carefully as possible, particular attention was paid to collaboration as it occurred, and to the aspects of the graphics or word processing software that seemed to cause the most difficulty for children.

Student Assessments

In addition to the collection of observational data, several assessments of children's use and understanding of the computer as a writing tool were conducted. Prior to software training, children's previous computer use, formal computer knowledge, and ability to use the keyboard were assessed. At the end of the school year, a posttest was administered focusing upon three areas related to children's computer writing: 1) attitudes towards computer writing; 2) procedural knowledge regarding word processing functions; and, 3) conceptual knowledge regarding writing and "saving" text at the computer. A separate assessment focusing on children's emergent writing at the computer was also conducted at this time. Each of these assessments is described briefly in the following paragraphs.

Computer knowledge, mastery, & attitudes. When the computers were first introduced into each classroom, the technical assistant conducted a brief assessment of children's previous exposure to computers, their familiarity with the names of various parts of the computer, and their ability to use the keyboard (see Appendix). This assessment was administered to individual children at the computer. Children were asked if they had ever used a computer before, and if so, where and for what purpose. Children were then asked to name the computer part pointed to by the examiner (screen, keyboard, drive, mouse). Kindergartners were asked to locate the letters of their names on the keyboard. They were then asked to type their names, with the examiner taking note of keyboard speed (first three letters typed) and search patterns. First graders were asked to locate and to type 6 letters and 2 numerals on the keyboard. They were also asked to locate the following function keys: escape, return, and space bar. Many of the first graders were exposed to these keys during their previous year's participation in Writing to Read.

In late Spring, a three part posttest (15-30 minutes) was administered individually to each child in both classrooms (25 kindergartners, 22 first graders; students who had enrolled mid-year were not included). The first part of the posttest consisted of a brief interview that focused upon children's attitudes towards writing stories on the computer and writing stories with paper/pencil, as well as upon their perceptions of how often they used the classroom computers. The purpose of this interview was to explore children's writing tool preferences (i.e., their likes and dislikes with regard to the two writing tools: the computer and paper/pencil). We were also interested in whether or not children viewed themselves as computer users.

The second section of the posttest was an assessment of children's ability to identify and carry out the basic word processing functions associated with the software used, *Muppet Slate* (kindergarten) and *Magic Slate* (first grade). The purpose of this section was to determine each child's level of mastery of the various functions, which are central to their ability to use the computer as a writing tool: selecting a new file, editing, saving, and printing text, loading an old file. A secondary purpose of this procedural assessment was to identify the areas with which children seemed to have the most difficulty, with an eye towards making informed recommendations regarding future software design.

The final section of the posttest was an informal interview that examined children's conceptions regarding "how you write" with a computer and their notions regarding the permanence of text written at the computer. Children were asked to talk about the differences and similarities between writing with a computer and writing with a paper and pencil, and to share their ideas about what happens to their text once it has been written in both contexts. The purpose of this interview was to explore the conceptions and ideas that children have developed in response to their computer writing experience. There is a certain amount of mystery associated with writing at the computer, even for adults, and we were interested to know children's theories about the underlying process, especially in regard to the somewhat abstract notion of "saving" text (e.g., Where does the story go?; Is text easily retrievable?).

At the end of the school year, Sulzby's emergent writing assessment (1986) was administered individually to 15 kindergartners and 17 first graders. These numbers represent a random sample of half of the children in each classroom, with the addition of children who were of special interest to the researchers and/or teachers. In this assessment, each child was first asked to talk about something fun or exciting that had happened to her recently. She was then asked to write about the described event or activity. Detailed notes were taken regarding the child's actions and verbalizations during the writing process. Finally, the child was asked to reread what she had written, once from the screen, and once from the printed out text (the order of rereading was alternated). The rereading portion of the writing assessment was tape-recorded and transcribed. Children's levels of writing and rereading were coded according to a set of categories based upon Sulzby's research. An obvious difficulty in using Sulzby's assessment for looking at children's writing at the computer is that the software used does not allow for scribble, drawing, or letter-like forms. While this limits the ability to depict the child's level of development, and to make comparisons with non-computer writing, the assessment did provide an opportunity to look closely at each child's computer writing and rereading, under controlled conditions.

The next sections of this report present the findings of the research. The findings are presented separately for the kindergarten and the first grade. The issues discussed are: the literacy environment of the classroom, training students to use the computers/software, the availability and use of computers, children's writing patterns at the computer, mastery of word-processing functions, children's conceptions regarding writing at the computer, and children's attitudes towards computer writing.

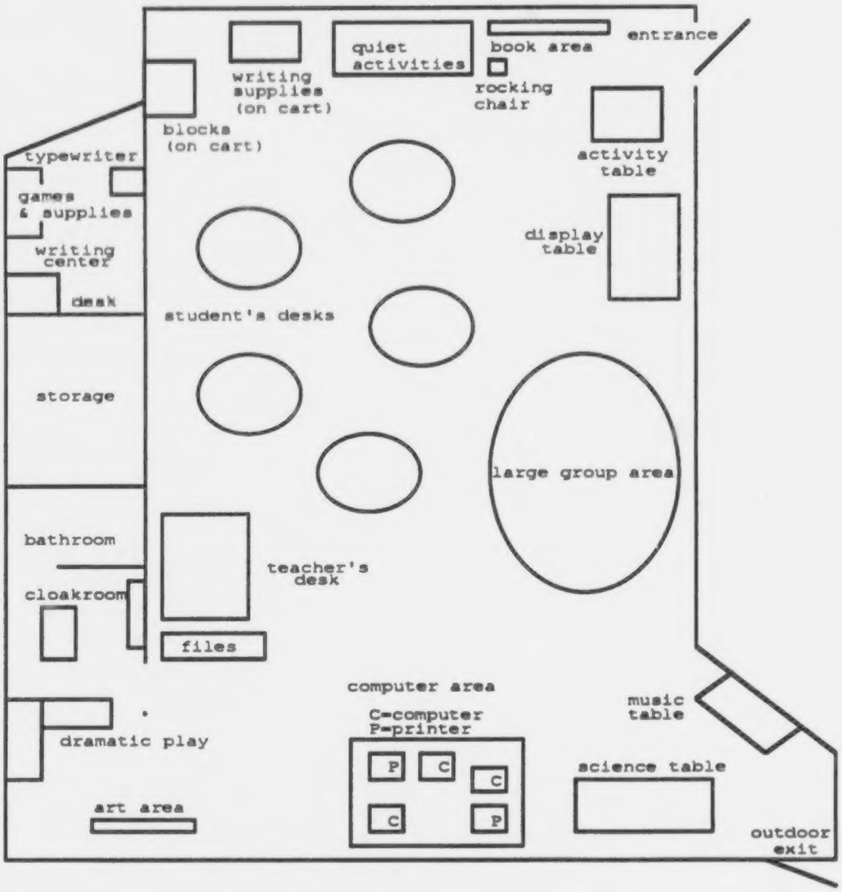
THE KINDERGARTEN CLASSROOM

The Literacy Environment of the Classroom

The computer and its software were introduced as simply another set of tools in the instructional environment of the classroom. How they are used is heavily dependent on the teacher's goals and expectations, and those of the students as they are shaped by the teacher. Accordingly, we started our research characterizing the classroom as a literacy environment prior to the introduction of the computers.

The Setting—Materials to Support Reading and Writing

The kindergarten classroom was arranged in learning centers organized around various activities (see chart, below): dramatic play, art, blocks, science, books, quiet activities, computers (beginning the end of November), and writing. The writing center was a small room adjacent to the classroom that was used on a daily, self-selected basis during station time and quiet activity periods. In it was a variety of writing materials, as well as letter-oriented activities: lined and unlined paper, pencils, markers, pens, a typewriter, blank books and book-making materials, magnetic letters, a chalkboard with colored chalk, sandpaper letters, and letter puzzles. The largest section of classroom space was taken up by the children's desks, circular tables seating five to six children. Pencils, crayons, and scissors were located in the center of each desk, available for use throughout the day. Near the classroom entrance, there was a bookshelf containing a collection of children's literature, beginning readers, as well as classroom published books. The classroom walls displayed a colorful array of posters, charts, and student's work. In addition to conventional text, many examples of emergent writing (child-produced) could be found on display at child's eye level throughout the classroom.


writing supplies (on cart)
quiet activities
book area
entrance
rocking chair
blocks (on cart)
typewriter
activity table
games & supplies
writing center
display table
desk
student's desks
storage
large group area
bathroom
teacher's desk
cloakroom
files
computer area
C=computer
P=printer
music table
dramatic play
P
C
C
C
P
science table
art area
outdoor exit

Activities To Support Reading and Writing

The school day typically began with a quiet activity period (15-20 minutes) during which children could choose from a variety of activities, including writing at their desks, computers, or in the writing center, and reading classroom books or storybooks from home. This period was often followed by a Calendar Time (5-15 minutes), with children gathered together in the large group area as the teacher led them through a series of math and literacy related activities (e.g., counting days of the month, graphing weather conditions, reading the names of the days of the week) based on the Math Their Way curriculum. This large group time usually led into Show & Tell (10-15 minutes). Each day 5 children would come to the front of the class and take turns giving clues about their Show & Tell items. Their classmates, equipped with chalkboards, chalk and sock erasers, wrote down their guesses (all forms of emergent writing appeared during this highly popular activity). The remaining portion of the school day tended to vary according to the day of the week and special events such as cooking projects, parent visits, or filmstrips. Most mornings included a "station time" when children could choose from any of the learning centers in the room, moving freely from one area to another for a 15-25 minute period. The writing center and the computers were popular choices during this time. Several times a week, teacher led "Alpha Time" lessons featuring "the Letter People" were given. These formal lessons emphasized letter-sound relationships and provided practice in writing letters. While activities such as this focused upon some of the conventional skills more traditionally associated with early literacy instruction, children were also expected and encouraged to read and write in their own emergent ways, for a variety of purposes.

Throughout the school year, children were invited to bring their favorite storybooks from home to share. These books were kept in a special basket alongside the regular bookshelf. Children selected these and other books often, usually engaging in "pretend reading" with a friend or to one of the storybook characters (stuffed animals) located in the book area. In addition to the daily opportunities for children to read to themselves or each other, storybooks were read to the whole class by the teacher on a regular basis. Singing and poetry recitation was a daily large group activity, with the teacher asking children to "read with me" while she pointed to the text and they sang or recited in unison. Conventional text was not the only source of reading material--children were also invited to "read" their own emergent forms of writing. Throughout these activities, the teacher used language ("Let's read this sentence together," "Read me your story.") that provided metalinguistic labels, as well as information about written language and the reading/writing process. In many different ways, children were encouraged to build upon their existing knowledge about written language, and to develop a growing sense of themselves as readers and writers.

All forms of emergent writing were modeled at the beginning of the school year and several times thereafter as "the different ways that kindergartners write." Children were given opportunities to write for many different purposes (e.g., letters to parents and peers, recipes for gingerbread cookies, field trip accounts, and puppet plays), sometimes on teacher-elicited themes (e.g., feelings, friends), but most often on self-selected topics. Whole class writing sessions (during which children would write individually at their desks or as a group dictating to the teacher) took place once or twice a week.

Group writing activities included the weekly production of a "Star of the Week" book in which each child would contribute a page about a chosen classmate, and dictated stories for which the teacher would act as scribe, with each child contributing a portion of the story. Class books such as these were added to the book shelf, available alongside the commercially published storybooks.

Sessions in which children would write individually usually began with a group discussion in which children were asked to "think in their minds" about their writing topic before going to their desks. As they wrote, children would often share their topics and ideas with one another, sometimes requesting assistance from a peer with the spelling of a word. During the writing period, the teacher circulated the room, pausing by individual children to take an interest in their work or to encourage children who were concerned about "spelling it the right way" to "write it your way." While she gave assistance in sounding out words, the teacher usually refrained from giving the correct, conventional spelling. When they had finished writing, children were often asked to reread what they had written, sometimes to the teacher, student teacher, or a parent while sitting in one of the designated "author's chairs," and sometimes to the whole class during large group sessions. In addition to these teacher-initiated writing sessions, children had numerous opportunities to write during self-selected activity periods.

Training Children To Use Computers/Software

Previous computer use. Prior to training children to use the computers, 24 children were interviewed regarding their previous exposure to computers. In the kindergarten classroom, 16 children (out of 24) reported having used a computer—5 in their homes, 11 at their parent's work place or at a friend's home). Of these children, one named writing, and five named ABCs, or typing as activities they had engaged in on the computer. Other activities mentioned were drawing and playing games.

A brief assessment was conducted to ascertain children's formal knowledge regarding the names of computer parts, as well as their ability to use the keyboard. Results indicated that kindergartners were not very familiar with the parts of a computer, although most were able to identify at least one part (8 were unable to name a single part, 5 identified the screen only, the keyboard was the next most commonly identified part, no child was able to identify the disk drive by name). All but one child were able to "hunt and peck" the letters of their names (some needed spelling assistance). Many children systematically scanned along each row as they searched for letters. Keyboard speed (based upon the first three letters of their name) ranged from 4 to 50 seconds.

Computer Introduction. In late November when the computers were installed in the classroom, they were introduced explicitly by the teacher as "writing tools." The teacher explained that the computers would be available at different periods during the school day "for writing stories." She emphasized that computers could break if they were not handled correctly, and stressed that children were not to use the computers until they had been trained by the technical assistant or the classroom observer.

Software Training. Software training consisted of a series of individual and small group (2-3 children) sessions, first with *Color Me* and then with *Muppet Slate* (conducted over a period of several months). Initial training sessions focused upon the basic graphics program and word processing functions (starting a new paper, using the mouse/keyboard to produce drawing/scribble/text, erasing). "Print," "save," and "load" were introduced after children had the opportunity to explore the basic writing functions.

Adult and peer assistance were needed for many of the students' return visits to the computer for writing. The technical assistant and classroom observer were often available for one on one assistance during the first few weeks of computer use. It was necessary for children to have plenty of time to explore, and to repeat the sequences of steps associated with various functions several times before they became automatic. Areas of particular difficulty for each of the programs used are elaborated on in the section on "Children's Mastery of Word Processing Functions," below.

Initially, all training was conducted by the researchers, with the teacher available (when not engaged in group instruction elsewhere in the class) to assist children as needed. In the early Spring, the teacher began conducting group training sessions at the computers. The focus of these sessions was a series of procedures she had devised in response to children's difficulties with saving and loading their stories, and with managing the operation of the switch box and paper feed of the printer.

During one group session, the teacher showed children how they were to save stories at one computer (which was to be used exclusively for writing), load them onto another computer (which was to be used for printing only), and then print them out. An advantage to this new approach was that it bypassed the need for the switch box and forced children to save first in order to print. A disadvantage was that it cut down on the number of computers available for writing. While this particular arrangement may not have been ideal, having the additional group instruction and a given set of procedures to follow seemed to aid children in their mastery of the targeted word processing activities.

Another group session focused on a four-step set of procedures for removing papers from the printer. Following our recommendation to make use of peer tutoring, the teacher had selected "Computer Helpers" who were trained to help other children with these procedures. During the session, the teacher reviewed the procedures and stressed to the class that children were not to remove their papers from the printer without the aid of a computer helper (whose pictures were posted next to the computer area). An important aspect of the training sessions was the demonstration at the computer (both on *Color Me* and on *Muppet Slate*) of the different stages of the story writing process.

Computer Availability And Use

In the kindergarten classroom, the computer was available on a self-selected basis during various periods throughout the school day. Regular periods during which the computers could be used included: morning activity time, quiet activity time, and station time. In general, individual children could elect to use the computer whenever they were not engaged in a whole class activity (e.g., group times, formal lessons). The computers were turned on first thing in the morning, with the programs pre-loaded and ready to be used throughout the remainder of the day.

While all children were given introductory training on both the graphics and the word processing software, the self-selected approach led to a great deal of variability in the amount of computer use per child. A few children rarely returned to the computers on their own once they had received their initial training. One child refused to come to the computers several times before he participated in the training, and did not return thereafter until posttests were conducted. Most children used the computers for writing at least 4 or 5 times, and some became regular users, returning to the computers several times a week. (One disadvantage of the self-selected approach is that it made it difficult for the teacher to keep ongoing records of each child's use of the computer.)

Although the computers were introduced from the beginning as writing tools, their integration into the regular writing activities of the classroom was an ongoing process. The computers had been in the classroom several months before they were included as an option during regular whole class writing periods. This was, in part, due to the fact that most children were still in need of a fair amount of assistance with the software at this time. It was also a reflection of the fact that the teacher's sense of familiarity and "ownership" in relation to the computers developed gradually over time. As the school year progressed, the teacher took an increasingly active role in encouraging children's use of the computer, and in devising classroom procedures to facilitate its use. By the early Spring, she was mentioning computers more often as an activity choice, and began conducting whole class training/review sessions, as well as story dictation sessions, at the computer. By the end of the school year, the computers were more fully integrated into the literacy curriculum, but they were still not as readily available as other writing materials during regular writing periods.

Children's Writing Patterns At The Computer

Children's use of the graphics program. The most common use of *Color Me* was drawing with the mouse. Sometimes children would also use the mouse to scribble or form letters, although this was a relatively rare occurrence. The keyboard was used to type letters, but not usually for the purpose of writing a story. Sometimes children would type labels next to their drawings (e.g., "cat"). More often, children would make multi-colored patterns by rapidly typing long rows of letters (or holding down a single letter key), one row on top of the other, alternating the color selection. [Note: When text reaches the bottom of the screen on *Color Me*, the cursor automatically returns to the top left-hand corner.] The resulting multi-colored designs were referred to by the children as "Magic Carpets."

As illustrated in the description just given, the graphic features of *Color Me* were particularly attractive to children and were often the focus of attention, despite the teacher's introduction to and demonstration of the program as a writing tool. Children usually referred to their activity at *Color Me* as "drawing" or "making designs," rather than as "writing." They were especially intrigued with the "Fill" command, which allowed them to fill sections of the screen with vivid color with a click of the mouse, and the "Big Dots" option, which put the screen in magnified mode and allowed children to edit their pictures pixel by pixel. Rather than being used as a self-contained context for writing, *Color Me* print-outs (which take up the top half of a 8-1/2" by 11" sheet of paper) were sometimes used in combination with writing with paper and pencil. In this case, the computer produced portion of the paper was treated as the illustration for the pencil written story at the bottom of the page.

One interesting use of *Color Me* that emerged was that of a story-telling tool, with one child enacting a story on the screen for an audience of one or more. The following observer's notes illustrate this use of the computer.

> 2/8/89: With the observer sitting next to him, Jonathon drew a section of red color at the bottom of the screen. At the top of the screen he had drawn a narrow stripe of brown from one side to the other, with a gap near the top center. Jonathon began making red lines from the bottom of the screen to the top, up through the gap in the brown stripe.
>
> Jonathon: Whoosh! Whoosh!
>
> Observer: I hear some sounds while you draw.
>
> Jonathon: Hot lava!
>
> Jonathon continued to draw the red lines, telling the observer that it was more hot lava, and that it was filling up with hot lava. He made brown dots around the center of the screen by clicking the mouse, explaining that these were the rocks falling down. He told the observer that he was going to show "the center of it"--"the bottom of the hot lava." As he filled a bottom section of the screen with yellow, he announced that the whole volcano was erupting.

A limitation of *Color Me*, in terms of its use as a writing tool, may have been the fact that its graphics components were just too attractive (which can hardly be regarded a design flaw, since it was intended to be used as a graphics program!). Its support of text (in terms of letter quality and basic editing) is minimal. In addition, its low resolution made it more difficult for children to engage in scribbling and hand-formed letters. What is needed, as already noted, is a tool that will allow children to move easily across all forms of writing, with equal support at all levels, and without some of the distractions of a program designed as a graphics tool. It is our contention that, given such a tool, we would be more likely to see writing that is more in line with what children do with paper and pencil.

Children's use of the word-processor. When using *Muppet Slate*, children were observed to use many of the letter based forms of writing that have been observed in other contexts (e.g., random letter strings, copying from environmental print, inventories of known conventionally spelled words, invented spelling). Many children who were writing primarily with scribble, drawing, and/or letter strings at their desks produced random letter strings at the word processor.

Random letter strings were of two types. The first type involved a more selective use of the keyboard, with the child typing a single letter at a time while alternating her gaze from keyboard to screen. Letter choices often appeared to be deliberate and sometimes the child would delete a letter as if s/he had made a "mistake," typing a different one in its place. These non-phonetic letter strings did not appear to be following a particular pattern, nor did they appear to be the result of letter-sound correspondences. The child was not observed to verbalize any words or sounds of words, or, if she did, the letters produced did not seem to relate to any of the child's utterances. When letter sounds were pronounced, there was a quality of "pretend writing" to the activity. That is, the child appeared to be acting out several aspects of the writing process, but did not appear to be composing a coherent text. Sometimes children would name letters as they searched for or entered them, but once again, this did not appear to be a breaking down of a higher level text (i.e., an intended word or story part). When asked to read the completed text, the child told an oral or written-like story and did not attempt to match the reading carefully to the text (other than sometimes running her finger rapidly along the lines).

> 5/31/89: Bethany begins her writing session by stating that, "I don't know how to write." She stares at the writing screen, then types "w" and "y," looking at each letter key as she presses it and checking the screen to see its display. She pauses, says "I messed up," and deletes both letters with the erase key. She then types a sequence of letters in a seemingly random pattern, sometimes whispering letter names as she types:
>
> cgkltilefbaxuflssedxop....
>
> As she continues writing, her eyes alternate between the keyboard and the screen, and at several points she stops entering letters and stares at the screen in silence. Occasionally she searches for specific letters, naming them as she scans the rows of the keyboard with her fingers. Several times she deletes letters just after having entered them, and at one point she uses the arrow key to relocate the cursor and delete a letter in the middle of a string. About mid-way through the writing session, Bethany begins typing rapidly, while staring at the keyboard only, before returning to a more purposeful-looking entry of text.
>
> When finished, Bethany rereads her one-and-one-half pages of non-phonetic letter strings with her eyes on the print, occasionally pointing to the text. Her first and second rereading are given in a reading intonation, but do not appear to correspond to the written text and differ from one another in wording and in where the spoken story segments occur in relation to where her finger points in text.

A second type of random letter string occurred when children "played typist" at the computer. The production of this sort of letter string differed from the above description both qualitatively and quantitatively, although both types of strings would sometimes be produced alternately by the same child in a single paper. When "playing typist," the child would use most, if not all, of the fingers on both hands, typing in a rapid fashion (if you closed your eyes and listened, it sounded like a typist). Eyes were usually glued to the computer screen, watching the letters spill out, row after row. Needless to say, this type of letter string resulted in a large quantity of text.

> 2/6/89: Tricia sits at the keyboard, using both hands to type letters in rapid succession. The letters quickly fill the screen. As she types, she comments to the observer: "I like to type. I used to use a typewriter to type. Now I use a computer."
>
> 3/14/89: Tricia continues to type letters in a rapid, random fashion as she talks. The letters spill out onto the screen, with no spaces in between, row after row. Half way through the second page, Tricia announces, "Now I'm finished."

It was not unusual for children using this approach to produce 2 and 3 page papers (3 pages is the maximum allowable on *Muppet Slate*). The size of their papers was often regarded among peers as an accomplishment worth noting, as illustrated by the comments of a child who was standing at the printer, watching her paper come out: "I made a big one. Mine is big. Latoya, mine is bigger than yours. I made three. It's comin out. Mine is big." (3/17/89)

A favorite "first" activity at *Muppet Slate* for many children (and a continued activity for some) was to type the letters in alphabetic sequence, following the rows on the Muppet Keys systematically from left to right, top to bottom. This activity was usually accompanied by a tuneful recitation of the alphabet song. Along similar lines, but at a more advanced level, one child made an "alphabet book," using invented and conventional spelling to produce a familiar pattern:

> [picture of heart] h For hort
>
> [picture of cake] c For cake
>
> [picture of bird] b For bird
>
> [picture of ballerina] b For balurenu

Patterned letter strings also appeared in children's computer writing. Developmentally, we know that young children produce non-phonetic letter strings long before they write with invented spelling. The transition from random letter strings to pattern strings seems to be an important one. We had previously speculated that the child's use of random versus patterned letter strings may appear differently when the child is writing at the computer rather than with a pencil. This difference might be attributed to the ease and accessibility of letters on the keyboard, as compared to the deliberate action of forming letters with a pencil. Indeed, many of the patterns we observed at the computer seemed to be a function of the layout of the keyboard, or of typing patterns, rather than the result of a conscious decision to place one letter in particular relation to another, as illustrated in the following examples.

Often the letters which are located near each other on the keyboard would appear together in a letter string: (ex. produced on the standard keyboard:) "czxxzxzxzxx...dtgtdfdtg..." (ex. produced on the Muppet alphabetic keyboard:) "MNGACDEF"

Sometimes children would place two or more fingers on different keys and press them repeatedly in rapid sequence, as in this example:

> jgjgjggj [picture]
>
> jfjgfjgjg [picture]

All children who wrote with invented and/or conventional spelling when using paper and pencil (and who chose to write using *Muppet Slate*) were observed at one time or another to write with invented and/or conventional spelling at the computer. The writing process in the two contexts was very similar, with the child often sounding out words and/or word segments aloud, then writing/typing the letter that seemed to correspond best to the sound, sometimes with the assistance of others.

> 3/16/89: Brent sits at the computer and tells the observer, "I got a new cat now. She's black. Her name is Sophie..." After showing off the scratches he as incurred while playing with his new kitten, he turns his attention to the computer. At the "Name your paper" prompt, he titles his story "THE CAT," then sits in silence for a moment, staring at the blank writing screen.
>
> Brent: Hmmm. It's hard for--I think it's a 'C' for /sss/.[1] (He types "c," then presses "Oops.")
>
> Arlene is walking by, sees Brent press "Oops," and interjects: No! Press this! (She presses the erase key.)
>
> Brent: /Sss/. (Types 'c.') /efff/. (Types 'f,' then 'e.' Then says to Arlene, who is standing next to him observing:) I'm trying to spell Sophie. (They begin sounding out together, from the beginning:) /Ssssooofffeee/.
>
> Arlene: Do you want to erase that? (Points to 'e' in 'cfe.') I think you press--(Presses erase key.)
>
> The two continue sounding out together:) /ooff/ (Brent types 'o.' He pauses, looks at the screen, perplexed. He erases the 'o,' then the 'f,' and types 'of.'
>
> Arlene: /Eee/.
>
> Brent types 'e' and rereads: Sophie! (And as he presses the space bar:) Space.

One difference between writing at the computer and writing with pencil was that children writing at the computer sometimes were observed to pronounce letter names more often, usually as they were searching for the letter on the keyboard. In addition, some children seemed to edit more readily when spelling at the computer, deleting more often than they were observed to erase when using pencil and paper. The ease with which they were able to delete and replace a letter at the keyboard may have increased the likelihood of such edits. On the other hand, the ease with which they were able to type the letter in the first place may have led to more initial errors.

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[1] "/sss/" is the convention used to indicate the child's sounds. In this case it indicates the sound of the letter "s" being made.

Children writing with invented or conventional spelling often paused to reread their text as they composed at the computer, more frequently than when writing with paper and pencil. Such rereading generally serves the compositional purpose of aiding the writer in planning what to write next (given what has been written thus far). This activity at the computer seemed to serve an additional purpose. The electronic page differs from a page of paper in which the writer's "place" is directly marked by the position of the pencil. Rereading at the computer seemed to aid children in locating their physical place in text—a response to their tendency to become disoriented or "lost" in the text on the screen. Regardless of the reason for more frequent rereading, this activity may have contributed to the fact that children were observed to revise more often at the computer. It should be noted that our comparisons between computer and paper/pencil writing are based, in part, upon informal observations of children composing at their desks. This is an area that demands more careful, and systematically implemented research.

Sometimes children used the computer to type a list of known, conventionally spelled words ("MOM," "no," "I love you."). One child used several computer visits to type her inventory of words in the following fashion:

> abdoggostopp
> opiceicemypopwe
> bgtopstop

When asked by the observer how she had learned to spell those words, she responded, "On signs. When I go past signs, I read them." She went on to explain that she had seen the word "ice" on an ice machine. (2/13/89)

Another child wrote a series of stories that were constructed out of her repertoire of conventionally correct spellings:

> i LOVE
> MYDOG I
> LOVE DOGS
> MOM AND
> CAT JULIA
> LOVES CAT
> MY DAD
> LOVES DOG
> AND CAT
> MOM AND
> JULIA AND
> DAD ME MY
> CAT AND DOG
> AND MY CAT
> (5/10/89)

In the course of exploring some of the keys and functions associated with *Muppet Slate*, children's attention was sometimes drawn to particular aspects of writing, such as spacing and capitalization. Many children were curious about the Muppet Keys space key (a picture depicting outer space) and the Muppet Keys upper/lower case key (which simply depicted upper and lower case letters). Children often used the space key to insert spaces between words with overt deliberateness, saying "Now a space" as they pressed the key or inserting more than one space between words.

> 5/22/89: Lauren types "my" and presses the space bar while saying, "I get a space for a new word." She then types "mommy is seselbe" and stops abruptly, saying, "Wait! I forgot to make a space! Then they'll think it's the same word!"

We do not know if the act of discovering the space key aided children who were close to making the transition to separating word units in paper/pencil writing (this is another area for future research). However, we do know that some children who spaced their words apart when writing with paper and pencil did not do so at the computer until it was pointed out to them by an adult or peer that there was a special key for this purpose. The child described above who wrote her inventory of words in a continuous line, for example, continued to produce similar inventories with words spaced apart after her attention was directed to the appropriate key. In addition to its conventional use, the space key was also used to arrange portions of text creatively on the screen.

Children explored the ability to switch easily back and forth from upper to lower case mode (the shift key on the regular keyboard was rarely used; caps lock was used slightly more often, but not as often as the clearly marked Muppet letter-case key), but rarely used capitalization in the conventional way. One child gleefully commented as she pressed the Muppet upper case key, "I wanta push 'em to big!" (3/14/89). At another time, one child pointed the Muppet upper/lower case key out to another child, saying "Push this and it will turn big." The child who was the recipient of this information proceeded to type a string of letters, alternating between upper and lower case while narrating, "Now big!" "Now small!" (3/17/89). In these instances, control, rather than capitalization, seemed to be the focus of the child's actions. Children took great delight in exercising their control of the keyboard in this fashion. At the same time, they were playing with the notion that "letters come in two sizes"--big and little. A by-product of this activity was increasing exposure to each letter in both it's upper and lower case incarnation.

There were at least two cases of children exhibiting a higher level of writing on the computer than they had previously demonstrated in their writing with paper and pencil. One of these cases was a boy who had not been observed (by the researchers or the teacher) to use any letter-based forms of writing in his stories produced in the classroom with the pencil, but who began to write with invented spelling at the computer. He elected to write at the computer often, sounding out words, and producing a series of short, narrative stories.

> Brent
> adventurv
>   mrse dhmn
> mce [picture of ghost] [picture of monkey]
> [picture of money] mne
>
> Read back as:
>
> "Brent's adventure.
> A dead man and a monkey."
> (2/3/89)

As is observed with children who are in transitional stages of writing with the paper and pencil, Brent sometimes had great difficulty reading back what he had written.

> 5/31/89: Brent has written a story about his father's weekend visit and is attempting to read back his text. He has written:

> we wtuw to thw
> bgm the tgr ad
> 10500 the bgm
> lsd lig we
> wtbac [picture of a jet] ie
> wit bac in the jat i
> mis him

Brent rereads from his text (eyes on print, pointing occasionally):

> "We went to the
> ballgame and the ballgame had
> ten fifty hundred. The ballgame
> missed..." (Pointing to 'lsd' in text:) "That doesn't say missed."

He seems confused, skips over a section of text and reads while scanning his finger along the last three lines:

> "We got on the jet. I missed him."

Another case of the transition to a higher level of writing occurring first at the computer was a girl who had primarily produced drawings and random letter strings with paper/pencil and sometimes with *Color Me*. She began taking an interest in invented spelling at the same time she began using *Muppet Slate*. Her first story was produced with much effort, and was returned to several times by her for rereading:

(3/13/89):

> my fafrt
> toymybig brnbr
> [picture of a bear]

Reread: "My favorite toy. My big brown bear."

On another occasion, Lauren wrote (5/22/89):

> my mommy is
> sesel beces she
> is nis and she
> hilps me she
> rees me a
> sorre

Reread: "My mommy is special because she is nice and she helps me. She reads me a story."

The point to be made here is not that the computer is a unique tool for advancing a child from one stage of writing to the next, but rather that it is a context in which these transitions do occur, just as they occur when children are writing with paper and pencil. For some children, the computer seems to be a particularly appealing writing tool. It is difficult to say which characteristics of the computer these children might find especially motivating or facilitative. Perhaps the ease with which they are able to produce letters at the computer is a more salient factor for some children, allowing them to attend more closely to other aspects of the writing process, such as letter-sound relationships. Perhaps aesthetics (e.g., the quality of the print, the borders and pictures) are an important factor. In our interviews with children regarding their likes and dislikes relative to computer writing, a number of issues such as these are raised (described in the sections on children's attitudes and conceptions regarding computer writing).

Just as children writing with paper and pencil have been observed to use different forms of writing for different purposes (Sulzby, 1985), a variety of forms of writing were used by children at the computer. That is, the same children would use different forms of writing on different occasions. For example, one boy who chose to do most of his classroom writing at the computer used *Color Me* to draw a story about "night time and the moon," (2/1/89). On another occasion, he used *Color Me* to enter some sort of list, which he seemed to be transcribing from a pencil-written list that he had first scribbled out on a piece of paper (2/20/89). The same child used *Muppet Slate* to write stories with random letter strings, ready-made pictures (which he sometimes read back as part of the story text), text copied from his T-shirt (2/6/89) and invented spelling. During a collaborative writing session with another child, this child acknowledged the distinction between different types of writing activities, with the comment, "We're going to write a real story...Not one that goes just letters. We're spelling!" (5/15/89)

Special functions and features associated with *Muppet Slate*. The ready-made pictures available on *Muppet Slate* were often used during the compositional process to generate and extend story ideas, as well as to illustrate stories that had already been written, as shown in the following examples.

> 3/16/89: Brent has just written text about his new cat, Sophie, and announces that he needs to get some pictures for his story. After accessing the picture book on *Muppet Slate*, he presses "c," arrows to a picture of a cat,[2] and inserts it, exclaiming "Yeah!" as he sees it displayed on the screen.
>
> Brent: Can I do lots of pictures? I want to do another picture. (He returns to the picture book by pressing the Robin key and begins scrolling through the picture choices.) A ball...there must be a ball somewhere. (He passes a picture of a block and presses the left arrow key to return to it.) Oh! Box, box, box. She plays with boxes. (As he selects the "box" and it appears on screen, he comments:) I like doing this. (He goes back to the picture book and says as he scrolls through pictures in alphabetical order:) I want to go all the way to "Z." (He comes upon a picture depicting a board game.) Game would be good because she walks over my games...(He selects the picture, returns to the picture book and continues scrolling, stopping at a picture of a heart.) H. Heart. How about that for love Sophie?
>
> 5/15/89: Brent and Tom began writing a story together, but were interrupted when Brent had to leave for Show & Tell. Continuing on his own, Tom entered a series of pictures--whatever seemed interesting. Upon his return, Brent begins constructing a story based upon the pictures Tom had selected.
>
> Brent (Pointing to each picture:) We ordered two pizzas and got some money for our kids. We got a dinosaur, and we got

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[2] An option within the *Muppet Slate* Picture Book is to access pictures by letter (pressing "c" to see all of the pictures whose name begin with this letter). Some children used their knowledge regarding letter-sound relationships to use this option, with varying degrees of success.

> (names other pictures). And we went bike riding (points to picture of bike).
>
> Tom: Two bikes!
>
> Brent concurs and inserts another picture of a bike. The boys decide that they should write "We went bike riding." After sounding out and entering text, they end up with "we wit he," which they read back "We went he," amused at their mistake...Amidst much giggling, Brent erases the "he" and types "p." The boys laughed as they reread "We went pee!"
>
> Brent: We went pee! Let's see if there are any water drips and we can put that on.
>
> Upon seeing a picture of a plane as they scroll through the choices in search of "drips," Tom suggests: "We could go on an airplane, then pee." Brent inserts the picture of the plane, and they continue to build their story based on ideas related to the pictures.

When children were typing random letter strings, pictures were often added as a kind of "decoration," with no indication of a relationship to as particular theme or story idea. In these instances, children would access the "picture book," arrow through pictures until they saw one they liked, select the picture, and then repeat the process. Often these pictures would appear at the beginning or the end of the entire string, sometimes there was a pattern to their insertion (e.g., a picture at the end of every line). During several observations, children had already initiated the printing process when they realized that they had forgot to "add pictures"--and would stop printing and add pictures before completing their turn at the computer.

> 3/14/89: After she has selected a border and started printing her random letter string, Latoya shouts, "I should've got the pictures that go in there!" With some assistance, Latoya stops the printer, displays her paper, and presses the picture book key. She presses the right arrow key repeatedly, moving through picture choices at a rapid pace. "I want that, that, that, and that," she insists as she scrolls past pictures that catch her eye. She selects a series of pictures, unrelated to any particular theme: an apple, a plane, another apple, a beach scene, and a ballerina, then announces: "That's it! Now I press 'Print?'"

For many children, pictures were an important feature of *Muppet Slate*, although they served different purposes and were not always used as for the purpose of composition or story-related illustration.

Children's use of the keyboard during writing with *Muppet Slate* was sometimes problematic. The keys on the Muppet Learning Keys were not as responsive as the keys on a standard keyboard. It was not unusual to see children using their thumbs, or alternating tired fingers, as they entered text. Often a child would press a letter key too lightly and it would fail to enter--a situation sometimes corrected if caught by the child at the time. One strategy used by several children was to use the Muppet Keys for special functions ("Stop," "Go") and to use the standard keyboard to enter text. [Note: The function keys on the Muppet Keys were clearly marked by colorful icons, in contrast to the abstract and often difficult to locate function keys on the standard keyboard.] When asked why she had switched to the standard keyboard for for entering text, one child commented, "Because it's my best." (1/25/89)

There is evidence that two features of the Muppet Keys facilitated text entry. These features were its alphabetic arrangement and its depiction of both upper/lower case keys. The Muppet Keys was the keyboard of choice for entering the alphabet (a popular activity). Even the children who usually used the standard keyboard for text entry would switch to the Muppet Keys for this purpose, and also sometimes for locating a difficult to find letter (they would scan the keys in order). In addition, sometimes children appeared to be aided by the depiction of lower case keys. This was repeatedly observed during the posttest, when children were copying text (the word "cat" spelled in lower case letters) from a model. Some children were tested on an older version of the Muppet Keys, which depicted upper case only. Almost all of these children needed assistance in locating one or more of the letter keys, a much higher proportion than children who were using the keyboard featuring both cases. After searching in vain for the lower case "a", one child commented, "Looks like a lower case. I can't understand it." (6/1/89)

The Character of Collaboration

Collaboration sometimes occurred at the computers, most often in the context of one child waiting for a turn at the computers and getting drawn into the action. Sometimes the waiting child would act as an audience, observing the writing process as it unfolded and listening to the writer's rereadings of text at various stages of the story. Sometimes the waiting child would take a more active role, offering technical assistance (e.g., "No, not that key! You wanna press erase! Right here!") or assisting with sounding out words and locating letters on the keyboard. It was also a frequent occurrence for a child passing on the way to another activity to stop and briefly get involved in what was happening at the computers, as in the example of Brent and Arlene, described above.

On several occasions, though not very often, children decided that they were going to write a story at the computer together. The example of Brent and Tom, already described, was one such occasion. On another day, Leanne, who typically wrote with invented spelling and conventional text, and Bethany, who was not yet at this level, collaborated upon a story that incorporated both of the girls' writing levels. Even the file name was an amalgam of the girls' names, using the first name of one child and the last name of the other. Both of the girls contributed ideas, building on one another's proposed story parts. Leanne acted as the scribe throughout most of the composition, entering text with the occasional help of Bethany, who assisted in locating letters. At two strategically placed points in the session, the keyboard was passed onto Bethany, who entered a sequence of numbers, the alphabet, and a random letter string--all coherently embedded in the story text (sections written by Bethany are underlined):

> [picture of balloon] a BALOON
> WAS FLOTING
> IN THE sky
> thar was a girl
> below the girl
> kowt it then
> she started to
> go up the she
> ---page 2---
> went home and
> ate then went

back she wontid
to cownt she
cowntid
01234567891011
then she stopt
agen she was 6
she sed
---page 3---
the alphabet
abcdefghijklmno
pqrstuvwxyz
she sed
gbhaidckfuuuuuu
vvvvvv?+,?wvplr
lhppnooqokpoipp
kkorowvwqpppu
jjwpqinnikniwki
then she stopt
---The End---

In general, this level of collaboration--with both children composing and taking an active role in all aspects of the writing process--was rare. This may, in part, have been a reflection of the developmental characteristics (i.e., social skills) of kindergartners. It may also have been a reflection of the particular social environment of the classroom. While cooperation was generally encouraged; collaboration in writing was not a specific focus of instruction or of classroom routines.

When children did work together at the computer, it was more often the case that one child was the designated writer, while the other child offered technical assistance, and/or acted as an interested observer. These different, though not necessarily separate, roles may have supported the writing process in different ways. Having an interested observer present during writing might aide the writer in developing a sense of audience--an aspect of composition that is often difficult for young children, but important to the writing process. An informal observation in the kindergarten classroom was that children were more likely to take an active and sustained interest in other children's writing at the computer than they were in other children's writing with paper and pencil. This could be due to a number of factors. For one thing, children were never in the position of having to wait for a turn to write with a pencil (a situation at the computers that lent itself to children acting as an audience). The physical display of text on an upright screen (which also happens to look like a television set) lends itself to public viewing. There may have been other motivational aspects that drew children's attention to computer activities (e.g., the colorful display, the novelty).

The role of technical assistant also served an important purpose. The child writing a story at the computer has several tasks, or levels of focus. In addition to the overall compositional focus, there is the task of determining what letters to enter (this focus takes different forms, depending upon a child's level of writing). A component of spelling or letter selection at the keyboard is the task of locating the letters. If text is to be altered in any way, separate procedures for deleting and/or inserting must be recalled and implemented, step by step. The provision of technical support reduces the load of these multiple cognitive demands upon the writer, allowing him or her to focus more clearly on story composition. A by-product of this form of assistance is that both children gain practice with and exposure to word-processing procedures, which will eventually require less cognitive effort once they have become more automatic.

Summary Remarks

These descriptions of children's writing at the computer provide an overview of the activities that occurred, and raise a number of issues for future research. All of the forms of emergent writing were observed at the computer, however the software that seemed to function best as a literacy tool *(Muppet Slate)* supported letter based writing only. We need to know more about how the computer functions as a literacy tool when it is supported by software that offers more complete support of all levels of emergent writing. Other questions that have been pointed out address the relationship between the functions made explicit by the computer/software (e.g., "space bar," "upper/lower case key") and children's incorporation of these functions into their thinking and behaviors as they engage in the writing process (inserting spaces between words, capitalization). A third area has to do with the ease with which children are able to enter letters and its relationship to the composition and editing process. Random letter strings produced at the computer tend to differ in both quantity and quality from their paper/pencil counterparts. Children also appear to edit more freely at the keyboard. These are issues that may or may not be developmentally significant and which demand more careful examination.

Children's Mastery Of Word Processing Functions

Overall, *Color Me* was more quickly mastered than *Muppet Slate.*[3] A number of children had initial difficulty manipulating the mouse. Several attempted to use the mouse directly on the computer screen after they were unable to synchronize their actions with the corresponding cursor movements on the computer screen. These difficulties disappeared after a few sessions of using the mouse to draw with *Color Me.*

Once children learned to manipulate the mouse, they quickly learned to use the multi-level, "point and click" bar menu at the top of the screen. Children who were unable to read the menu choices conventionally used the icons and/or screen location to identify their choices. Most of the basic commands were mastered with little difficulty: selecting new colors, selecting "tip" and text size, erasing, starting a new paper, filling portions of the screen automatically with color, and using "magnify mode" to edit their picture pixel by pixel. Children learned, mostly through self-discovery and peer support, to erase using a variety of techniques: selecting the "erase page" command, selecting "Oops," and scrubbing or filling the area with the background color. While children usually printed out their papers, they often neglected to save and rarely found occasion to reload those pictures or stories which they had saved. Children who used*Color Me* on a regular basis were observed to save and load, however. Since the end of the year assessments were not given on *Color Me*, we are not in a position to provide any descriptive statistics on the mastery of these functions.

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[3] That is, given the same number of visits. It should be noted children were given software training on *Color Me* before they were introduced to *Muppet Slate*. This should not have interfered with their mastery of *Muppet Slate*. The two programs differ enough so that "proactive interference" should not have been a factor. In some ways, becoming generally familiar with the computer through *Color Me* might have facilitated the use of *Muppet Slate*. However, the cognitive demands associated with learning a new set of procedures are worth considering. In general, *Muppet Slate* is a more complicated program in terms of its functionality and design.

Muppet Slate posed a number of interesting challenges for the kindergartners. Many were quickly able to overcome their initial difficulties with the procedures for selecting menu choices (i.e., using the arrow keys to get to choices, remembering to press "Go" to select), starting a new file (i.e., remembering to select new, naming the paper), and printing (i.e., selecting "Print," selecting a border, pressing "Go" when ready to print). Most children had no difficulty entering text (although the hunt and peck approach was often a tedious one for those who were searching for particular letters), and deleting backwards, letter by letter. Rarely were children observed to use arrow keys to relocate their cursor to selectively delete or insert text. The children who were observed to do this were usually inserting additional letters into a random letter string or inserting pictures into their text, rather than selectively editing to correct spelling, alter text, or add pictures.

The functions of "Save" and "Load" were not usually used without prompting, and, for many children, required assistance until well into the school year. This was interesting to us because, on *Muppet Slate*, the procedures for printing are very similar to the procedures for saving and loading files, and children seemed to have little difficulty printing out their papers. We speculated early on that one of the reasons for this discrepancy in use may have been because "save" and "load" are more abstract conceptually. That is, the purpose and meaning of "saving" or "loading" a paper is difficult to grasp from a concrete perspective. From the child's point of view, these are functionally vague and unobservable processes, whereas printing a paper renders a physically concrete and obviously useful result. Furthermore, "saving" and "loading" are not directly analogous to any activity associated with paper/pencil writing. Therefore, we reasoned, it was not surprising that children had trouble executing these functions.

Interestingly enough, when "save" and "load" were made a part of the printing process (see Software Training section for description), children began to learn the procedures for saving and loading. The posttest revealed that for some children, their conceptions of these functions remained somewhat narrow in scope due to this association (described below), but their procedural knowledge of these functions was solid. The one difficulty that continued to be associated with "Load" had to do with the fact that, once a file was loaded in *Muppet Slate*, "Write" had to be selected in order to get the paper displayed on screen. This problem rarely appeared in children's spontaneous computer activity, because they rarely wanted to go back to an old paper other than to print it (which simply required that "Print" be selected once the file was loaded). It did appear, however, with at least one third of the children during the post test when they were asked to show the examiner a story they had already written (these children had to be prompted to select "Write" when the Main Menu reappeared on the screen after the story had been selected).

In the posttest to measure mastery of *Muppet Slate* functions (see Appendix), children were asked to: start a new paper, enter a title for their paper (their name), type the word "cats," and insert a picture of a cat. At this point, the examiner pointed out that "This says 'cat,' but there is only one cat. We'd better make this word say cat instead of cats. Erase this 's' (pointing) so that it just says 'cat.'" The point of this task was to look at the child's command of basic editing functions (e.g., using the arrow keys to relocate the cursor and delete), rather than the child's ability to spell. In the remainder of the posttest, children were asked to save and print their text, and to load an old story. Each item on the posttest was given a numerical score (total score=23), based upon the child's ability to perform the task independently, with some assistance, or with complete instruction only.

The posttest was individually administered to twenty-five kindergartners. Not surprisingly, the variability of computer use in the kindergarten room led to a fair amount of variability in children's performance on the posttest. Children's overall scores fell into a nearly even distribution, which lent itself to three categories of performance: high (19-23, mean of 21.2), medium (15-18, mean of 16.7), and low (7-14, mean of 11.4). The three groups were determined as follows: high scorers were able to execute all of the basic functions with little (a single prompt) or no assistance; medium scorers needed more assistance (requiring more than one prompt or guided instruction with at least one, but not more than three, functions); low scorers required a great deal of assistance (requiring prompts or guided instruction on several or more functions).

Children's posttest scores corresponded to amount of classroom computer use, both in terms of observed amount of use and in terms of children's reported amount of use. Seven out of 9 of the high scorers, 4 out of 9 of the medium scorers, and 1 out of 7 of the low scorers said they used computers a lot, as opposed to a little. Scores also correlated with children's statements regarding whether or not they enjoyed writing stories at the computer, although the high and medium scorers were not distinct on this dimension. Eight out of 9 of the high scorers, 8 out of 9 of the medium scorers, and 2 out of 7 of the low scorers reported that they liked computer writing.

Most of the variability between scores could be found in the following activities: starting a new file, selecting pictures, and editing. Most of the high and medium scorers could start a new file without assistance, whereas most of the low scorers needed step-by-step prompting. All of the high scorers could edit with very little, if any assistance. However, most used an "undo and start over" editing strategy, erasing the picture of the cat as well as the 's' rather than relocating the cursor and selectively deleting. About half of the medium scorers and all but one of the low scorers needed a great deal of assistance with editing. Interestingly, there was less variability overall in children's performance on "Save," "Print," and "Load," perhaps due to the whole class instruction that was given in this area.

Children's performance on the posttest sometimes reflected their individual preferences in program use. Two children who often used computers to write random letter strings did well on all of the writing functions (starting a new file, selecting pictures, editing text), but had difficulty saving and loading their papers. One child who had stated that he "just liked to use the computer to make pictures," scored well on all functions (including selecting pictures) except editing.

Many children, even those who performed well overall, became hesitant or confused at various stages of the posttest. On a number of occasions, a simple indirect prompt, such as "What do you do next?," was all that was needed. A general conclusion is that children who used the computer on a regular basis had mastered the basic word processing functions, but many were in need of further practice before these procedures would become more automatic.

Children's Conceptions Regarding Writing at the Computer

Conceptually, writing is a symbolic activity in which characters (i.e., letters) and forms (e.g., scribble) are used to represent objects and events (first order symbolism), or to represent language about objects and events (second-order symbolism). The physical task of writing with pencil and paper might also be described as a concrete activity, in the sense that the act of writing itself (i.e., putting marks on paper) is experienced directly in relation to the fine motor actions of the writer. Each letter is formed through deliberate action--if it is large, it is because the writer has physically extended the size of each component part. If it is bold, it is because the writer has exerted pressure. The order and the orientation of each letter in relation to the others is determined by a purposeful forming of each part of the text. In other words, written products themselves are concrete manipulables. Once produced, they can be folded or torn, saved in a folder or thrown in the trash can, or altered in some way using a variety of tools.

In contrast, when writing with the computer, various aspects of the writing process become much more automatic and abstract. With the press of a key, a letter magically appears on the screen. A press of another key, and it is instantly deleted. A different set of procedures causes an entire story to be hidden away in some unseen location. Text can be altered, "saved," and even "thrown away," but not directly acted upon. The writing process is relatively removed from concrete manipulation, operating more completely on an abstract plane involving the manipulation of symbols and the execution of procedures that are indirectly related to their on-screen results.

Given these differences, we address the question: How do children make sense of the process of writing at the computer? We have described some of the ways that children write using the computer. Clearly, young children are able to master many of the basic procedures associated with this activity (though not always with ease). What are their underlying conceptualizations with regard to these functions? When asked to compare writing at the computer with writing at their desks with pencil and paper, what do children cite as the salient differences? Do they have any theories about the relationship between their actions at the keyboard and what happens on the computer screen? What is their understanding of the abstract notion of "saving" text at the computer? Do they regard their text as permanent and retrievable, even though they cannot physically locate or visually confirm where it has been "saved" to?

Given the limited verbal and metacognitive skills of young children, these are difficult questions to address. Our approach was informal and exploratory. After completing the procedural component of the posttest on word-processing, children (25 total) were interviewed regarding their conceptions of the process of writing and saving text at the computer. The interviews began with the examiner describing how children wrote with a pencil ("You take your pencil and you make marks on your paper, like this..."), then asking the child to talk about how writing at the computer was different. In the second part of the interview, the examiner gave the example of saving pencil written stories in a writing folder or a back-pack, then asked the child what happened to the stories they had written at the computer (as distinct from the print-out). Throughout the interview, the examiner asked follow-up questions to clarify and probe the child's statements. In the first part of the interview, follow-up questions focused upon how text gets produced at the computer. For example, if a child said that he "made letters," he was asked to describe how that happens at the computer. In the latter part of the interview, questions focused upon the location and the permanency of the text. For example, if a child indicated that his stories were on the computer, the examiner asked if they were still there when the computer was turned off and/or whether he could get his story back later.

How Writing Gets Done

Children's descriptions regarding "how writing gets done" at the computer often focused upon the physical aspects of the writing task (pressing keys vs. using a pencil), and the automaticity of entering/deleting text.

> You press buttons instead of using your hands. You still use your hands but you press buttons. You don't use a pencil.
>
> You just press the letter that you want. (What happens then?) It comes up on the computer. (How do you think it does that?) Because the control that you push. A letter pops up and then it stays.

> You push it and the words come on like this (demonstrates by pressing letter keys). If I push erase, then it goes (demonstrates, deleting letters with the erase key).
>
> You see, you have a keyboard and you write something down. And you see the letters and sometimes they're small and sometimes they're capital letters...On the computer, you write, you just press a key. And when you write something, you use a paper or pencil or something, and you make the letters with your hand.
>
> You push the keys. You just press them and it gives you letters...By pressing you get what you want. After you press the keys, it's on the computer. After you print it, it's on paper.

This focus on the physical aspects may have been determined, in part, by the interview itself. Providing children with an example of how one writes with a pencil certainly called attention to this particular dimension. However, when probed further, most children were unable to speculate about the underlying process, simply responding that they didn't know how it worked. Several children made analogies to the typewriter.

> Press it and it makes a "V." It has something like a typewriter and it has a "V" on it. And it has ink in it. And it stamps it out. If you want lower case, you can have lower case. But I don't want lower case.

A few children addressed the issue of control, speculating that the keyboard somehow "told" the computer what to do, or was connected to "a control" that linked the child's actions with what happens on the computer screen:

> Well, you press the button, and I think it tells the computer that it wants that letter. So it puts that letter up on the screen...(You mean you have to tell the computer by pressing what to do?) Cause you can't just say you need the letter "R!"
>
> There's something that goes to the control, and what happens is that the control actually has this wire and it connects up to the computer. And it makes the computer work. And it makes this work for the computer because when you push a button, it goes on...

Other children's responses consisted of a description of the procedures associated with various aspects of writing at the computer, as in the following example:

> You have to put the paper on, then you have to go back to print. You gotta pick a border...

Saving Stories

When given the examples of how paper/pencil stories get saved and asked to describe what happens to stories written at the computer, most children talked about the process of saving their stories to a disk (some were confused about the location). All but a few children insisted that they could get their stories back, even if they were not printed out and if the computer was turned off, as long as they had saved their stories. Most children described "save" in terms of putting the story "in" or "on" a disk, sometimes this was characterized as a relocation of the story from the computer to the disk. A few children did not identify the disk on their own, but when asked what it was for, associated it with saving and/or getting their stories.

> The paper is on your disk. But when you put it [the disk] in, paper gets into your disk and then when the paper gets into your disk, it just saves your story.
>
> If you don't save it, you can't get it back. It fell off your disk or something....If you save it, you can get it back because it's on your disk.
>
> (What happens when you turn off the computer? Does your story go away?) No. (Where is your story then?) It's printed out. (Okay, you have a copy that you printed out. Is it anywhere else?) In the computer! On the disk! (How does it get there?) By saving it. It puts it on a disk and saves it.
>
> On your disk. Your story is in there.
>
> If you save it, it's on the computer.
>
> It's different on the computer. You have to save it on the disk. (What happens to your story when you save it?) Well, it takes it out of the computer and puts it on the disk.
>
> It's on the computer. Up here. It goes down to your disk so you can print it out.
>
> You print or you save them. You take it off your disk.

In addition to the above somewhat open-ended interview, children's understanding of the purpose for saving was directly addressed in the context of the procedural posttest. After being instructed to save his text (with assistance given, if needed), the child was asked, "Why do you save?" The most common response to this question (9 out of 25 children) focused upon the idea that you save your story so that you can come back and work on it some more, or finish it.

> You can write on it again.
>
> So you can do it next time.
>
> So I can save my story if I want to put more on it.
>
> If you go away, you can do it later.
>
> So you can go over to print them or we can save them to finish it.
>
> Case you don't have time to finish it...You don't have to leave the computer on.
>
> Because when people tell you to go and do something else, some other people would come along and it won't be your story. They would erase it.
>
> If teacher says clean up and I'm still working, I can find it later because it's on my disk.

The next most common response (5 children) was that you save stories so that they do not go away:

> Because when you want them, you can just get them on your disk. If you don't save them, it won't be on the disk.
>
> So your story doesn't go away.
>
> If you want to see it again, you put your disk back in and it would be on it.
>
> So you have it on the disk and you can press load and get it back.

Several children said that they saved stories so that they could read them later (3 children), and one child said that he saved stories as a reference source for future writing.

> After a long time, you might want to read it.
>
> So if I want to make the same kind of one or if it has the same kind of pictures I forgot. That's why sometimes I save. (Why do you need the same kind of writing later on?) I mean if I forget how to write that word, I go back to "Save"--I mean go back to "Load," and push it to the one where I remember where it was, and after that I remember that word.

For some children, the act of saving seemed inextricably tied to the the process of printing. This may be because these children were equating the two procedures, failing to distinguish between "save" with "print." However, the fact that the question was asked as they were saving (not printing) text reduces this possibility. It is more likely that the approach implemented by the teacher, which made saving, loading, and printing a routine sequence of procedures, led some children to think of "save" in more narrow terms as "something you do in order to print."

> So I can print them.
>
> Cause I want to read it...You can read it like a book. Sometimes I write three pages.
>
> Because I like to take stories home and show them to my mom.

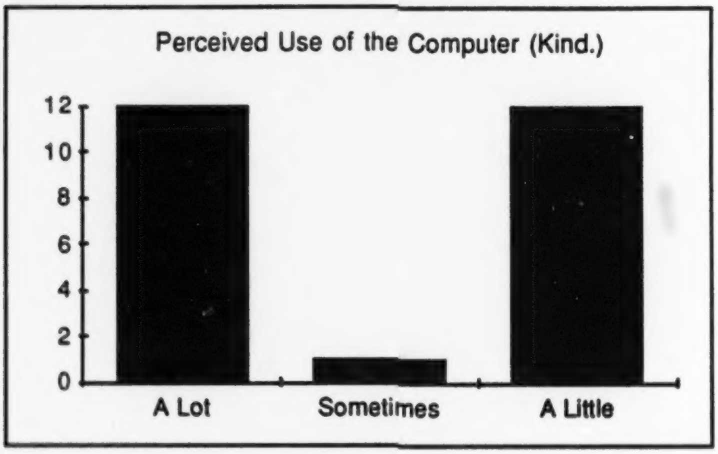
Overall, children's comments regarding how and why text is saved on a computer reflected a surprisingly strong understanding of the procedures and the purpose associated with this concept. Children seemed to regard their "saved" computer stories as permanent and retrievable, although they were sometimes confused as to their exact physical location. Children's ideas regarding the differences between writing at the computer and writing with pencil and paper focused upon the physical aspects of entering text, and the automaticity of the keyboard. Only a few children were interested in and/or able to comment on the underlying process or issue of control. In general, children's responses reflected their growing awareness of both the capabilities and the limitations that characterize the computer's use as a writing tool at this level.

Children's Attitudes Towards Computer Writing

When the computers were first introduced into the classroom, all but a few children were eager to have their turn learning to use *Color Me* and *Muppet Slate*. As the year continued, about one third of the children maintained a high level of interest, while another third chose to use the computers very infrequently or not at all. Those who did write at the computers on a regular basis expressed many positive feelings about the activity, and were often visibly absorbed in and delighted with various aspects, such as inserting pictures, picking out borders, typing, and watching their papers print out. The following spontaneous comment overheard one day in the computer area is illustrative:

> I like computers very much. They're fun to use. I like the
> Puppet (sic) Slate. (2/13/89)

At the end of the school year, children (25 total) were interviewed regarding their perceived amount of computer use, their choice of computers and/or pencils for story writing, and "what they liked best" about writing in these two contexts. In terms of overall computer use, twelve children claimed to use the computer "a lot," one "sometimes," and twelve "a little." When asked what they used the computer for, fourteen mentioned for writing or stories, and twelve named drawing. Other uses named by children were spelling words (2), printing (2), typing (1), and playing games (10). The "playing games" category was most often associated with computer use in the home. Several children said that they enjoyed using computers at home, but did not use them as often at school. Two children cited the shared access as a reason for their limited use ("Too many people" is the way one child put it).



All but five children said that they liked to write stories. When asked whether or not they wrote stories at the computers and/or at their desks with paper and pencils, most children responded that they engaged in story writing using both tools. Seventeen children said that they wrote stories at the computer, while three said they did "sometimes," and five said that they did not. Eighteen children said they wrote with paper and pencil, three said they did sometimes, and four said they did not. Of these responses, three children claimed to write at the computers but not at their desks, and five said that they wrote at their desks, but not at the computer. Overall, children's perceptions regarding computer use were positive. However, there was a definite subset of children (approximately 23%) that felt they used the computer very little, if at all.

All children who said that they wrote stories at the computer were asked what they liked best about this activity. Most children responded in general terms, saying that they liked it because it was fun. One child said that computers helped him "be creative," and another said that when writing with computers, "It's more possibilities." Several children said that the pictures in *Muppet Slate* were their favorite part of computer writing. A small number of children mentioned other features or functions specifically associated with the software (color choices) or the computer (typing at the keyboard vs. writing with a pencil, printing):

> They help get writing done. (How?) They get it done faster, like if you're in a hurry.
>
> That you can type, not write. You just have to press and it comes out.
>
> You don't use the pencil and it's not paper. It's fun to do.
>
> Cause you can choose different colors that the crayons can't do.
>
> I can print out lots of different things.

Some of the responses given did not seem to be tied to any unique characteristics the computer; however, it is notable that these general aspects of the writing process were associated by the children with this particular context:

> It helps me make up stories.
>
> I like best about writing stories at the computer because I can read somebody my story that I wrote...I can give stories to my mom, my dad, or my brother and they like stories I make for them.
>
> Cause its fun and I learn new words. (You learn new words?) By sounding things out. (Anything else?) I like sounding things out on the computer and I like writing and drawing on computers.
>
> Like spelling words and helping me to remember what I'm trying to write and then help me so I keep them on paper and bring them out.

When asked what they liked best about writing with paper and pencil, some children's responses followed a similar pattern of reflecting characteristics of the writing process in general, rather than aspects of writing with a pencil in particular:

> Learning new words.
>
> Fun to read.

A number of comments were based upon comparisons of writing with paper and pencil with the more difficult aspects of writing at the computer (locating letters on the keyboard), or with limitations of the software (not being able to use all of the forms of writing).

> Cause I don't have to use--I don't press buttons. All I do is use my hands.
>
> It's easier, because I don't have to look everywhere to find the letters that I need.
>
> You can write your handwriting. You can scribble, and on the computer you can't scribble. And it's fun.

> That you don't have to really write it. You can just do scribble.
>
> Because writing is just like playing writing.
>
> Coloring.

Some of the children's responses indicated that what they liked best was the flexibility of having different writing tools to choose from. As one child put it:

> If you write with your hand, it's different. If you write with a
> computer, it's different...when it's different it's fun.

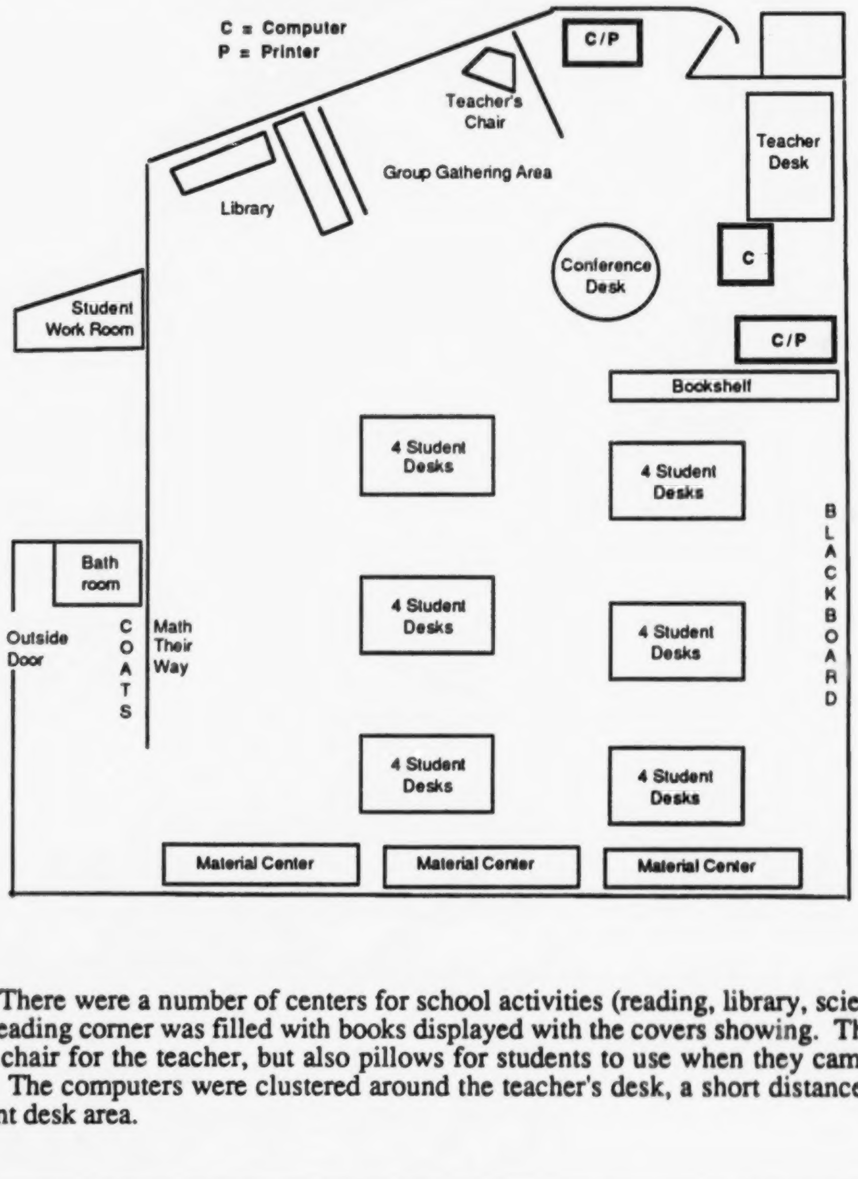
By the end of the year, most of the kindergartners identified writing as one of the primary uses of a computer (compared to a single child at the beginning of the year). This perception of its use was an important part of what CIEL hoped to gain by making computers available for writing in the classroom. We had hoped that children would come to regard the computer as an alternate writing tool, alongside other more traditional writing tools.

THE FIRST GRADE CLASSROOM

The Literacy Environment In the Classroom

The Setting—Materials to Support Reading and Writing

The first grade classroom was a small angular room. It was carpeted and painted in vanilla tones. The look was fresh but subdued. There were large quantities of print on the walls. The alphabet was across the top of one wall. On the facing wall was an intricate Math Their Way Calendar containing many words associated with the concepts of days of the week, daily activities, weather, weeks, and months. Taped to the top of each student's desk was the child's name and a number line.


C = Computer
P = Printer
C/P
Teacher's Chair
Group Gathering Area
Library
Teacher Desk
C
Conference Desk
C/P
Student Work Room
Bookshelf
4 Student Desks
4 Student Desks
BLACKBOARD
Bath room
Outside Door
COATS
Math Their Way
4 Student Desks
4 Student Desks
4 Student Desks
4 Student Desks
Material Center
Material Center
Material Center

There were a number of centers for school activities (reading, library, science, etc.). The reading corner was filled with books displayed with the covers showing. There was a story chair for the teacher, but also pillows for students to use when they came there to read. The computers were clustered around the teacher's desk, a short distance from the student desk area.

Activities To Support Reading And Writing

There was a predictable routine to the school day. The morning was reserved for language arts and the afternoon for math and science, although the teacher did not hesitate to develop language arts ideas in science and vice versa. When the children entered the room in the morning they were free to work at their seats on a ditto, or on a writing or art task of their choosing. The next activity was the Math Their Way calendar. This 10-15-minute activity was centered around identifying the day's date, weather, and the events of the day as well as developing a sense of number and sequence. Next was a three-part reading/writing activity (60 minutes). It began with a group activity in the discussion center designed to stimulate students to think about ideas or words that they could use in their writing. The children then went to their desks to do "regular morning writing" for about 20 minutes. This was followed by students returning to the discussion center to share their writing. Students then had a recess period (15-30 minutes) followed by reading (20-30 minutes). Lunch time ended the reading period.

Literacy activities began before the school year. In August, the teacher sent home a letter to each student. She described herself and her family and invited students to write a letter in reply describing their family and what they did for the summer. An examination of these letters indicated that a large number of students could already form letters and use at least invented spelling (perhaps with the help of their parents). There was a range of writing levels, but the assignment had been taken very seriously and the text was quite extensive for the most part. Many letters were in the student's own handwriting; only a few had been transcribed by an adult. There were several examples of more pictorial forms of writing, suggesting that at least some of the parents were comfortable with their child sending in a less-than-conventional product.

At the beginning of the year almost every activity in the morning was geared toward writing. On the second day of class, after the students did drawings before class, the teacher announced: "If these are drawings you want to write about during writing time, you can certainly get them out!" Another day, in the Math Their Way calendar time, she picked up a card with the number "8," asked what it reminded them of ("girl with a long skirt"), and suggested that they could write about that later.

Story time was specifically designed to stimulate ideas for writing. On the second day of classes the teacher read a story and then announced that it was time for the children to think about the kind of story they would write about that day. When she passed out the paper for writing time, students could choose one of three types of paper: unruled, wide-ruled, and narrow-ruled. This was done, she explained, to allow students to use all forms of writing. While the teacher encouraged children to write using the highest level of their ability (thus, children who could write with letters were often expected to do so), she was supportive of all forms of writing.

Training Children to Use Computers/Software

Previous computer use. Prior to training children to use the computers, children were interviewed regarding their previous exposure to computers. Most of the twenty-four children in the first grade classroom had used computers for writing at some time. Nineteen had already used a word processor in kindergarten through the school's Writing to Read (WTR) program. Those 19 had composed individually at computers almost every day for the last three months of kindergarten, using forms ranging from letter strings to conventional writing. In addition to writing with a word-processor (IBM's *Primary Editor*), the computer-supported component of the WTR lab included a series of tutorials focusing on phonemic discrimination and recognition. All but one child reported having had informal experience using computers prior to beginning the first grade. The most common type was playing games.

A brief assessment was conducted of children's formal knowledge regarding the names of computer parts, as well as their familiarity with the keyboard. In general, the first graders, as a group, had considerable informal experience with and formal knowledge about computers. Only four out of twenty-four children were unable to name any part of the computer. The mostly commonly named parts were the keyboard (16 children) and the screen (16). Seven children were able to identify the mouse by name, and six children labeled the disk drive, often incompletely ("for disks"). A few children did not know the formal names for computer parts, but were able to describe the functions associated with them ("That's what moves the arrow around;" "That's where you put the disks in"). Children were asked if they could identify on the keyboard the function keys used as commands in *Magic Slate:* the escape key, the return key, and the space bar. Most children were able to locate both the return key and the space bar (18). Two children recognized one or the other, while four children could not identify either of these keys. Ten children were able to locate the escape key, while 14 could not. Children were additionally asked to locate on the keyboard six letters and two numerals (depicted on cards). The speed for locating and typing these characters ranged from 12 to 59 seconds.

Software Training. The first grade introduction to *Magic Slate* was divided into five sessions, each one lasting between 10-30 minutes. The goal of the introductory sessions was to enable the student to access the writing screen and enter text without assistance (see the Appendix for a complete description). The first two sessions were conducted in small groups of three or four children at the computer. Children were introduced to the procedures for selecting the menu choices offered within *Magic Slate*. At the third and fourth sessions, students returned to the computers in pairs. The pairs entered text that they had already composed together with paper and pencil. They were introduced to the basic editing functions (e.g., delete, insert), as well as how to quit, save, and print a file. The fifth session was a whole-class review of the word processing functions and procedures. Student handouts (taken from the *Magic Slate* student guide) were provided at each of the sessions, with activities to reinforce the concepts presented (e.g., coloring in specific function keys on a worksheet depicting the computer keyboard). The total amount of introductory training time per child (including whole class review) was approximately three hours.

As in the kindergarten classroom, during the initial phases of computer use extensive adult and peer assistance was needed by many of the children. In an assessment conducted shortly after initial training had been completed, it was found that 40% of the children were able to carry out most or all of the basic word processing functions on *Magic Slate*.[4] The initial, as well as continued areas of difficulty are discussed in the section on "Children's Mastery of Word Processing Functions."

The technical assistant or the classroom observer were available for individual assistance almost every day for the first few weeks, and on a weekly basis for several weeks thereafter. Several of the children who had mastered the program early on were placed by their peers in the role of "resident experts," called upon for assistance when needed. The first graders often used each other as sources of information; whenever one child "discovered" a new function (page insert, type styles), the news spread quickly. Many children chose to work in pairs at the computers, and in the process provided one another with technical support and assistance. This level of support, coupled with the fact that children made regular visits to the computer, led to a high level of overall mastery by the end of the school year.

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[4] While this percentage may seem high, it should be noted that most of the first graders had already worked with a word processor. In fact, previous experience with Writing to Read actually interfered with learning some of the functions within *Magic Slate*. Overall, first graders mastered the software more quickly than kindergartners. It should be noted, however, that in addition to being a year older, first graders were trained more intensively and systematically than the kindergartners.

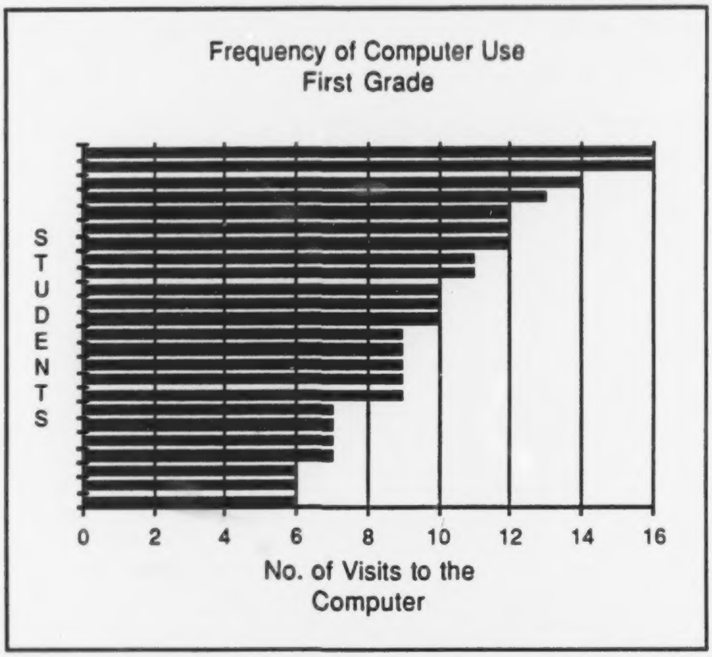
Computer Availability And Use

The use of the computers in the first grade classroom can be viewed as falling into several phases. The formal introduction to *Magic Slate* occurred at the end of October, when computers were first installed in the classroom. In early November there were a number of whole-class and group writing exercises. Text was composed orally as a group, with the written product transcribed onto the blackboard or a piece of paper; as a last step, the edited text was entered into the computer. Beginning in late November, students were occasionally given the option to use the computer at writing time as an alternative to working at their desk. The teacher used self-monitored turn-taking to equalize opportunities for students (students were to check their names on a list whenever they had a turn, making sure that their number of turns was equal to others). At this point in the year, writing time varied in length from 15-30 minutes, but tended toward the shorter period.

By the end of January, and for the entire second semester, working at the computer was routinely offered as an option for students during writing time. During this period writing time occurred three to four times a week and typically lasted 20-30 minutes. The teacher would ask who wanted to work at the computer. She used a class list to distribute the turns equitably (offering a turn first to those students who had not had a writing session at the computer in the longest period of time). When chosen, a student had the option to work alone or select a partner.

January was a transitional month for the teacher. It was during this month that several things occurred that caused her to question the role of the computer in the overall picture of writing development. A key issue was simply that of management. During writing time the teacher circulated among student desks, observing and helping those who were writing. The computers were somewhat removed from the rest of the student desks. Students working together at the computers were sometimes noisy, and just beyond the sphere of the teacher's control. For example, one day Joshua and Grant played a game. One would dictate letter-by-letter the spelling of a word while the other typed. At the end of the word one would shout out the name of the word. Then they switched positions, exchanging control of the keyboard, sometimes with a little friendly struggle. Later the teacher commented to the observer that the boys were just "fooling around." Another time Stacy took the book *Clifford* to the computer and began copying the text directly from the book. The teacher commented that Stacy could not read what she was typing. She questioned the value of this activity, associating this particular choice with the computer. Another source of ambivalence may have come from the fact that even in January, many students still needed technical help—e.g., what to name a file and how to print or save a file.

In the course of addressing these issues and concerns with the researchers, and increasing her own involvement in computer writing, the teacher became more comfortable with some of the more exploratory and emergent writing activities that occurred at the computer. At the same time, she began to take a more active role in monitoring its use. In March when the teacher made a presentation on her experiences to a statewide computer conference she felt there were enough good choices being made by the students to endorse the use of the computer as another writing tool.



During the second semester there were eighteen weeks during which students had the option to do their writing at the computer. Everyone in the class chose to use the computer at some time; the minimum number was six and the maximum 16. The patterns of selection were quite varied. Most students took a turn one day and then not again for several weeks. Some took their turn early in the semester, others did not select a turn until March or April. Some students, when they found a partner with whom they collaborated well, worked together three to five times within a few weeks, advancing a single story. Similarly for some students working alone; when they were working on a story they liked, they tried to return to it several times during a few-week period when a turn became available.

Children's Writing Patterns At The Computer

A Publishing Tool

The first uses of the computers were not for composing, but for final publishing of a class or group writing product developed in the manner the teacher had always used. In late October, after a field trip, students worked at their desks in pairs, hand-writing thank you letters to adults who had assisted with the trip. The teacher corrected each letter for spelling, capitalization and punctuation during conferences with the authors. The students then entered their corrected letters into the computer with assistance from an adult. This took 15-30 minutes.

The "hunt and peck" approach to typing made this a time consuming activity. Colored stickers were added to the end of each row of keys to help children locate letters. Children negotiated turn taking (every other word or line). They took an active role in assisting one another with the task of finding their place in the letter or locating specific keys. Many children were already familiar with the basic function keys (return, delete) from their prior experience with Writing to Read. Most children appeared interested in the task; a few became visibly restless as they waited for their partner to complete a turn at the keyboard. Several children engaged in exploratory actions: e.g., pressing an unknown key to see what would happen, holding down letter keys to watch the letters fill the line or screen, or holding down the delete key to see the letters disappear.

In another assignment students worked in groups of two or three composing answers to questions about animal characteristics as part of a science lesson. (For example, why do fish have fins? why do deer have antlers?) The original writing was done with pencil on a half sheet of paper, with the question written at the top by the teacher. Children's answers included letter strings, invented spelling, and some conventional writing. The teacher planned to have each group share their story orally with the rest of the class, edit it, and then enter it into the computer. For reasons of time, some groups edited their text—with the help of an adult—as they entered it into the computer. Each group spent 15-25 minutes at the computer.

In another variation, the teacher had the entire class develop a story or letter while she transcribed it on the blackboard. One student was then asked to transcribe the text by hand and give this piece of paper to another student to enter the text into the computer. Multiple copies of the resulting text were printed, and students took them home to read to their parents.

In mid-November, during the regular writing time, and at other times during the day, the teacher began making the computers available for individual writing. Turn-taking was accomplished first by drawing names, and later by going through an alphabetical list in order. Students usually volunteered when asked, anxious to try out the new computers. Over the course of six months extensive observations were made of students working at the computer, and descriptions of what and how they wrote with the computer are reported here. Occasionally comparisons are made with the writing of students working with a pencil, but time did not allow systematic comparisons of computer and non-computer writing.

A Tool For Composing

There was great variation in how students used the computer. This variation refers both to differences in the writing production of different students, and to variations for any one student's writing production from one turn to the next. On one day in December the following was observed. Aaron used his turn to type numbers and symbols. When he was finished he held down the delete key, erased all of his work, and quit the program without saving. Grant created an "ABC boock" consisting of one page of invented spelling of words. When he finished he printed it out, took it to his desk and proceeded to illustrate it. Julie typed a story in invented spelling:

> I pet my cat ol nghit. I like my cat my cat likes me.
> *I pet my cat all night. I like my cat my cat likes me.*

Mark typed a joke he had read in a book from the classroom library.

> y do fiyr man war red sispandrs? ...two cyp tr pantsup.
> *Why do firemen wear red suspenders? To keep their pants up.*

Meanwhile, at their desks the other students were writing with pencil and crayon using a wide range of styles. The only consistent difference between the computer writing and the desk writing was that most desk writing had some form of drawing in addition to the text, and the drawing was frequently done before the letters or words were written. The inability of the word processor to support pictorial forms of writing had eliminated this possibility and forced the students to use only the characters available on the keyboard. If the student wanted to draw, s/he had to append it to the text after it was printed.

Beginning in January a number of pairs of students wrote at the computer and produced texts which were more extended and at a higher level than typified their solo seat work. The two Jennifers produced the following over a three-day period.

> 1/19:
> The snow qwen was pride she lvde in the nytro porl
> *The snow queen was pretty. She lived in the North Pole*
>
> 1/20:
> and she was mrede. and she hade chldn. and kiss her hmbnd. and pat har chidn in bed.
> *and she was married and she had children and kissed her husband and put her children in bed.*
>
> 1/21: (printed by hand at the bottom of the page)
> and went to Bed whthHer. hmbnd The End (drawing)
> *and went to bed with her husband. The End.*

The teacher commented after the second day that this was more text than either had produced with a pencil at their desk. Several aspects of the computer experience might explain this. Although in many activities in this class (e.g., reading to one another) students were encouraged to work together, it was not very common for students to collaborate at the pre-writing or composing stage. The small number of computers led the teacher to encourage two students to work together from the very beginning of a writing assignment. The text generated in a collaborative effort was joint in the sense that the letters on the screen have no signature, identifying them as the product of one or the other members. The text was "saved" on disk and easily retrieved on subsequent days for additional work. This makes it very easy to extend the story.

Julie and Joseph began writing as a pair on January 19. Julie was a high-level writer. Joseph was a very creative child, always ready to tell a story, but he had never ventured to put his stories into print at his desk. Instead, he would make elaborate drawings which he would read from when asked. In the following story Joseph and Julie both came up with the ideas—when asked whose story it was they both replied without hesitation that it was both of theirs. But Julie was the scribe controlling the keyboard while Joseph sat in a nearby chair or on the floor.

> 1/19:
> A long time ago
> thaer was a catsell
> and in the catsell
> thaer lived a king
> and a quein and
> that quein haed
> a babby. the
> babby was 1/2.
> the babby liked to play in the catsell.but she
> hated to get bust aruoned.
> 1 day her mother bust her aruoned
> and she didened
> like it one bit.

she haed to do some thing.then
she sunck her
fothers sord
and she cut
the backuemcllyner
in haf. so her
mother woled not
suck her up.becous
she was so tinny
A long time ago there was a castle, and in the castle there lived a king and a queen and that queen had a baby. The baby was 1/2. The baby liked to play in the castle, but she hated to get bossed around. One day her mother bossed her around and she didn't like it one bit. She had to do something. Then she snuck her father's sword and she cut the vacuum cleaner in half so her mother would not suck her up because she was so tinyy

1/20:
as a babby.but
the backuemcllyner was so houmungus
that it was biger
then the babby .the babby was 2
now.happy birthday yeled her parents,but
]her
mother just gave her a spanking for recing the backuemcllyner.one night she haed a nightmaer that the backuemcllyner
as a baby. But the vacuum cleaner was so humungus that it was bigger than the baby. The baby was two now. Happy birthday, yelled her parents. But her mother just gave her a spanking for wrecking the vacuum cleaner. One night she had a nightmare that the vacuum cleaner

1/23: (in pencil at their desks)
aet her up. it was skary.
in the nighitmaer. the next day
the Vackuemcllyner
aet her up. her
mother was varry sad
then she had a nother Babby
and she was happy again
the end by Joseph & Julie
ate her up. It was scary in the nightmare. The next day the vacuum cleaner ate her up. Her mother was very sad. Then she had another baby and she was happy again. The end, by Joseph and Julie.

Each day Joseph and Julie had an opportunity to print out their story and read it to the class. They read it, taking turns line-by-line. Joseph scanned the text with his eyes, apparently reading the words. (In the early months of computer use those who worked at the computer always wanted to print out their product and read it to the others in the class.)

While these two collaborative efforts are somewhat impressive, they are not typical. The following example illustrates how variable are children's responses to the computer—probably as variable as their response to paper-and-pencil tasks. On Joseph's next turn at the computer he chose to work alone. His goal was to enter numbers in sequence from 1-300. Jennifer T., when paired with a new partner—Shannon—produced a less ambitious product (than the one described earlier:

TENNY TINE PRISES
TEENY TINY PRINCESS

THE TENNY TINE
PRISES WET OWT TO
PLAY THE TENNY TINE
PRISES WET
HOM
The teeny tiny
princess went out to
play. The teeny tiny
princess went
home

Aaron, who in December was typing only numbers, was still doing this on a turn taken in mid-January. When an adult observer asked, "do you know any words?" he proceeded to type "cat," "dog," and "mom." After the adult moved away he went back to typing numbers and symbols and then ten pages of blank lines generated by repeatedly pressing "enter." (each "enter" leaves a non-printing symbol on the screen.) Derek began his turn by holding both hands over the keyboard, secretary style, and depressing keys as though he were a touch typist. When an adult observer evidenced some interest he asked if he could print out the random letters he had typed. With a little more prodding he loaded his one other saved story. This was a story in invented spelling, several sentences in length, about his cat catching rabies.

In late February the teacher read a story to the children about an old lady feeding potatoes to soldiers. Following her normal procedure she suggested that this story might serve as the basis for a story they would write. As usual, the teacher's lead was picked up by some and ignored by others. Consider these variations. When Erin and Stacy (two high level writers) went to the computer on this day they typed numbers from 1-117, and strings of "*" and "@" (which they called seashells). Shannon did two things during her turn. First she composed a story:

THE CESES IS NOT
HENO SHE NOT HENO
BY SHANNON
The princess is not here.
She is not here.
By Shannon

After saving this story she got the book *A Dozen Dogs* from the classroom library and copied six words from the first sentence before the end of writing time. Stacy took the book *Clifford* to the computer and began copying text.

As these examples illustrate, children's production activity at the computer varied widely. For individual students use of the computer varied from one visit to the next. Sometimes it appeared to be in response to a particular task, other times in response to the ideas and stimulus of a partner, and still other times in response to personal whim. The variability in their computer products, however, seemed little different from the variance in their paper-and-pencil products. Another thing to note is that all of the examples show the computer being used for literate activity—translating oral stories to text, copying existing print, or creating number or word lists. This result is not inherent in providing children with computers; it can be attributed at least partially to the norms for computer use set by the teacher.

The Character of Collaborative Writing

This first-grade teacher was very supportive of students working together collaboratively. After some experimentation in previous years she decided that two-person groups work best at the first grade level. This year she had students pair up for reading, taking turns reading aloud to one another. They also worked together on projects in math and other subjects. Early in the school year she trained students in a few essential skills of working together (sharing tasks, avoiding destructive criticism).

With only three computers the teacher was happy to have students work in pairs at the computer. She would select a student to work at the computer and then let that person choose a student to work with. The person selected was not required to participate. Sometimes the person asking had to try several students; sometimes the person would give up and write alone.

If one views creating written text at the first grade level as transcribing an essentially oral form of expression, the collaborations at the computer provided ample opportunities for students to scaffold for one another in the various tasks of translating the oral story to print.

There are several tasks to be accomplished in the creation of a text. There is the creation of the story line itself, the translation of the spoken idea into words, the physical task of finding the appropriate keys and pressing them, and the adjustment of typed text to meet the rules of language understood by the students ("You capitalize this word because it's the name of someone").

In this class collaborative writing meant working together on all aspects of the text, including pre-writing, writing, and editing. The most frequent form of collaboration involved the joint creation of a story with relatively equal roles between two students. A topic would be decided upon quickly, often arising from the teacher's suggestion or from experiences in the students' lives, such as a TV show. Very little time was given to planning the overall story; the story unfolded one idea at a time. A sentence or sentence fragment was proposed by one student, and agreed upon or revised by the other student. Then came the task of translating each word of the fragment into a defensible spelling and finding the appropriate keys on the keyboard. Spelling the chosen word was a matter of negotiating a defensible string of letters. Both students watched the screen intently, continually re-reading previous text. The re-reading was most intent around the word or sentence under construction. But there were frequent reviews of larger chunks of the story or of the entire text as though this was necessary to keep in mind how the story was developing. During these longer rereadings errors were frequently caught and changes made. The most common errors regarded spacing (too many spaces between words; or no space between two words) and spelling. To the extent one or more members of the pair knew certain rules of grammar (e.g., capitalization or punctuation) then these would be discussed as they related to a phrase or sentence.

The pairs varied in the roles played by each member of the pair. Shannon and Valerie shared equally in every task, as shown in this exchange.

Valerie: Let's make it about a dog with puppies!

Shannon: Yeah, the dog has lots of puppies!

Valerie: She had puppies

Shannon: (eyes very wide) She had baby puppies!

Valerie: (types s-h-y)

Shannon: No; e at the end; s-h-e.

Valerie: (changes y to e; then types h-a-d) I'll just write pups

Shannon: Pups? p-u-p-s.

Between each word, alternately typed by Shannon and Valerie, the students consulted on symbols to place between words. They always typed two symbols (e.g., =+) between every word. As with the text, each was flexible about the choice. "How about an '=' next time?" "O.K."

Most pairs were comprised of two people who varied in their talent for each of the tasks and who showed a different predilection to perform each task (or to let the other member perform it). Julie and Joseph (discussed earlier) proposed story elements about equally. But Joseph was happy to let Julie do most of the text entry, including decisions about spelling and grammar.

Some collaborations were more of a struggle if one of the pair was more dominant and less inclined to share. For example, in the Snow Queen story described earlier, the second day of collaboration (1/20) began with Jennifer U reading the sentence from the previous day: "The snow queen was pretty. She lived in the North Pole." She then proposed that the next sentence should be "and she was married," and her partner, Jennifer T, quietly assented (or at least did not disagree). Jennifer U was in front of the keyboard. She said aloud "and" and then the letters of the word, "a-n-d," as she searched for each letter on the keyboard. She did not offer the keyboard to Jennifer T. Next she said "was-w" and found the "w" quickly. She then said "a-s", but could not find the keys. Jennifer T found them first, reached over Jennifer U's hands and pressed the keys. Jennifer U said aloud, "why aren't you letting me do it?" Jennifer T said nothing and simply stared ahead. It was a long time before Jennifer T had a turn to either propose a word or enter it.

A few pairs did what might be called parallel writing. They took turns entering text, but there was no common story development. This seemed to occur when one or both of the students were at a low level of literacy development. Derek and Ben S. were writing together. Orally they agreed to write: "Derek has a VCR. Ben S. has a VCR." Ben then took the keyboard and typed "Ben S." and passed the keyboard to Derek who typed a random letter string. Ben got mad at Derek for not typing his name and proceeded to delete Derek' letter strings. After some struggling, and after Ben completed the sentence "Ben S. has a VCR," Derek typed "Derek has a VCR." With this the boys decided they were done and printed out the story.

Occasionally a collaboration did not work at all, despite a good relationship between the members of the pair. This appeared to happen when there was no role for one of the members to play. Joshua and Paul tried to collaborate. Joshua was at a conventional level of development, but Paul was still at a drawing stage. He could contribute orally to story ideas, but he had little to contribute at text entry and could not re-read what was on the screen.

Collaborations did not always involve the development of a story, but they did always involve some literacy activity. Laura and Stacy collaborated on copying text from the book *Clifford*. Laura said each word and spelled it while Stacy typed. Daniel and JASON created four pages of "words that I know" copied from various posters and lists hanging around the room. This activity was popular at one point, and various pairs of students competed to get the longest list of words.

When students wrote at the computer they frequently chose to work with another student. When they wrote at their desk collaboration was not very commonplace. This may have been the result of the teacher encouraging it in one place and not the other. It may also be that the context of the computer station is more conducive to collaboration. The text on the screen does not obviously belong to one or the other author, and the task of typing can be easily shared.

The collaborative activity appeared to be a useful educational process for both members of the pair. It usually entailed discussing the oral story and selecting the most compelling story line. The stories had to be translated to print, and in the process there was usually a discussion of many of the choices associated with the translation, ranging from what "sounds" right to what "looks" right. And the continual re-reading of the text out loud provided practice in reading. While the roles varied from one pairing to the next, there were almost always opportunities for each member to scaffold the other in one aspect or other of the writing process.

Children's Mastery Of Word Processing Functions

By the end of the school year, all but one first grader had mastered most of the basic word-processing functions within *Muppet Slate*. During the posttest, most of the children were able to start new papers, write stories, do simple edits, save and print their stories, as well as load old stories, without assistance. For many of the children, achieving this level of mastery was a gradual process, requiring extensive support initially and repeated practice. In this section, we describe some of the initial, as well as the continued, problems encountered by children as they learned to use the word-processor. Quite often, these areas of difficulty were related to functions in word processing for which there were no analogous activities in paper/pencil writing.

Getting Started: Using the *Magic Slate* Menu/Naming Files

Most of the first graders had already been exposed to "menus" within other software programs, and they quickly learned to identify and select functions listed in the *Magic Slate* menu. The use of icons aided children who were unable to read the menu choices. During the introductory training sessions with *Magic Slate*, the technical assistant noted that about one-third of the children had difficulty using the arrow keys to make menu choices (pressing one arrow repeatedly rather than choosing arrows selectively based upon direction). This initial difficulty was resolved with practice. The use of arrow keys to reposition the cursor during editing, however, was a continued source of difficulty (see discussion below).

Within *Magic Slate*, the first thing children were asked to do after selecting "New" on the menu (to start a new paper) was to name their file. This procedure was initially confusing to many children, who had difficulty understanding that "file name" was not necessarily the same as the title of their paper (quite often their title, if they had one, exceeded the length limitations for file name). There is no good analog for "file" with paper and pencil writing. Children's writing folders had their names on them, and the folders contained all of their writing, differentiated (if at all) by the paper titles. Furthermore, whereas two papers could share a title, each file must be given a different name. These rules and routines were learned with practice, although it's not clear what children thought about the notion of a file.

Pretest

Following the training sessions, children (24 total) were briefly assessed on their procedural knowledge of *Magic Slate* commands (see Appendix for a complete description). At this time, 40% of the children were able to execute most of the basic word-processing procedures with little or no assistance. A listing of the component skills that were readily mastered, as well as those requiring additional assistance follows.

Skills Easily Learned

Identifying Menu screen
Identifying 'New' on the Menu
Moving highlight with arrow keys
Naming a file
Locating 'Print' on the Menu
Locating cursor to insert text
Erasing with Delete key
Using Control-P for page breaks
Handling disks

Skills or Procedures Not Easily Recalled

1. Pressing Return after Menu selections
2. Responding to a 'File not saved' prompt
3. Recalling Control-Q to return to Menu
4. Recalling need to save file before quitting
5. Responding to formatting prompts before printing
6. Recalling ESC command after printing
7. Loading files after moving disk to new computer
8. Recalling sequence to delete: locating cursor to left of word or letter, Control-D, pressing Return
9. Recalling sequence to insert when in typeover mode: locating cursor, pressing Control-E, typing, pressing Control-E to return to typeover

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At this early stage of children's use of *Magic Slate* children appeared to have the greatest difficulty with the following general areas (numbers correspond to component skills, above): executing commands that required multiple, rather than single, keystrokes (3, 8, 9); recalling commands (which were inconsistent within the program) for returning to the Main Menu (3,6); responding to on-screen prompts that required conventional reading skills (2, 5); implementing procedures for saving and loading files (4,7); implementing multi-level sequences that involved manipulating text on the screen (8,9). In the following paragraphs, each of these areas is briefly examined. It should be noted that some of these areas apply to specific design features within *Magic Slate*, while others apply to word-processing functions more generally. As we observed children throughout the months following the pretest, we found that some of these initial difficulties were overcome with practice. Many children devised their own strategies in response to particular problem areas, as described below. Other areas remained problematic through the end of the school year.

Double Keystroke Commands. While double-keystroke commands would objectively appear more difficult to execute than single keystroke commands, our observations indicated that they were not, in themselves, obstacles to mastery. Double-keystroke commands were readily learned by first graders if they were associated with popular functions, such as page break (Control-P) and type styles (Control-O). Control-Q (the command to exit to the Main Menu at certain points in the program) remained problematic because it was used inconsistently within the program (see discussion below). Other double-keystroke commands associated with advanced editing functions were rarely, if ever, used, because children's editing remained at a very basic level.

Inconsistent Commands. At different stages within the program, *Magic Slate* requires different commands for returning to the Main Menu (at times the escape key is used, at other times the double keystroke command, Control-Q, is required). This inconsistency was confusing to children. Many children did not recall which command was needed at a given point. Once they learned these two commands, however, their response was to employ the strategy of "if one doesn't work, then try the other." This approach always got them back to the Menu, although children often expressed frustration when their first choice did not work.

A general observation is that the inconsistent use of commands within a program, as well as inconsistency between programs, interferes with children's mastery of the program(s). For example, children who had learned to "Quit" by pressing the escape key in Writing to Read had difficulty remembering how to "Quit" when using *Magic Slate* (which requires Control-Q). A recommendation to software developers is the standardization of the basic commands associated with various function keys. In the meantime, children may require additional support in the form of visual aids or frequent reminders before they are able to adapt to these inconsistencies.

Prompt Screens Requiring Conventional Reading Skills. *Magic Slate* contains several prompt screens about saving and printing text that most of the children were unable to read. For example, after selecting "Print" on the Main Menu, the child is presented with no less than three screens presenting questions regarding formatting and type of printer. To compensate, children simply pressed the return key whenever a screen with instructional text appeared. Most recalled the need to press "Return" three times to advance from the 'Print' Menu selection, to the actual printout step. While children learned to adapt to this particular feature, their initial mastery would have been aided by the use of prompts designed for children who are not yet able to read conventionally, or by a more straight forward printing procedure.

Saving and Loading Files. Children learned to "print" before they learned to "save" and "load" their papers. We have speculated (see kindergarten section) that young children may have difficulty with the abstract notion of "saving" and "loading" a file. These activities are only remotely analogous to how paper/pencil products are saved and retrieved. First graders were able to master these procedures with practice, however, and many took pride in displaying their list of files to an interested observer. One aspect of loading files that continued to require assistance is described below.

In *Magic Slate*, after loading an old file, the Main Menu reappears and the child must select "Edit" (the equivalent of "Write" in *Muppet Slate*) in order to have their paper displayed. While most first graders were able to select "Load" and select a file from their list without assistance, a number of children became confused when the Main Menu, rather than their paper, appeared on the screen. Rather than selecting "Edit," these children would request assistance at this point, or would repeat the procedure for "Load," only to find themselves returned to the Main Menu once again. This feature was no doubt intended by the designers to offer flexibility—once a file is loaded, the menu offers a range of choices (edit, print) in relation to the file. From the child's perspective, however, the fact that a file can be "loaded" but not seen (until another command is implemented) was confusing.

Multi-level Sequences. Some of the more advanced word-processing functions within *Magic Slate* were demonstrated to, but rarely used by, the first graders. At the time of the pretest, it was found that two of these procedures—switching between typeover/insert to alter text, and selectively deleting letters or words within previous text—were not recalled by the children. As children gained experience using *Magic Slate*, these functions remained either unused or, in the case of the typeover/insert option, misused.

Several months after introducing the computers, we attempted to simplify the program by eliminating the option to choose between typeover and insert mode.

Initially, the program options in *Magic Slate* were set up to allow children to switch back and forth between typeover and insert mode (by pressing Control-E). A number of children used the Control-E command to switch from "insert" (which was the default) to "typeover," not because they wanted to type over text but because they preferred the way the cursor looked in typeover mode (a rectangular box in which letters appeared as they were typed, versus a straight line). Not understanding the purpose of these different modes, these children failed to select insert when they wanted to type in additional text in the middle of a sentence. Consequently, they became confused and frustrated when they unintentionally typed over their text. After repeated episodes of children accidentally deleting their text in this fashion, we adjusted the program to operate in insert mode only.

Other editing functions remained available, and were occasionally attempted with varying degrees of success. A detailed discussion of children's approach to editing follows.

"Navigating" and Manipulating Text on the Electronic Page

One of advantages of the word processor that is most often cited is the ease with which it allows one to edit text. Indeed, first graders were often observed to make on-line corrections as they wrote, deleting and replacing a letter or a word immediately after entering it. Higher level editing, in which the writer goes back to alter previously written text, occurred much less often. This is not surprising, given that novice writers are generally less likely to revise or edit text. However, even beginning writers find a need to alter their text on occasion. For example, sometimes when rereading their stories on the computer screen, first graders would find that they had misspelled a word, or that they had missed a word altogether. Sometimes they would decide to replace one word with another. While some children would attempt such edits on the word-processor, others insisted upon writing their corrections in by hand, using a pencil on the print-out. Our observations of children's editing attempts indicate that there were several aspects of editing on the word-processor which may have been particularly difficult for the first graders.

Editing functions that involved a series of commands to manipulate text on screen (such as deleting words in the middle of text) can be characterized in terms of several levels of complexity. Procedurally, these functions require a complicated sequence of commands that are difficult to master. Given limited cognitive resources, the effort required to implement these step-by-step procedures might interfere with the compositional focus. Conceptually, these functions implicitly assume an understanding of both the malleability and the stability of written text. There may be important developmental or novice/expert differences with regard to understanding these characteristics. Furthermore, these characteristics (i.e., the "malleability" and "stability" of text) take on new meaning in the context of word-processing. As the first graders soon discovered, the task of "navigating" and manipulating electronic text on the computer screen differs in many ways from the task of altering hand written text on a piece of paper. In the following paragraphs, we explore some of the challenges and obstacles encountered by children in the process of gaining a sense of the electronic page.

The use of arrow keys during writing, to reposition the cursor in order to selectively insert and delete text, remained a source of difficulty throughout the school year for some children. Unlike placing a pencil or an eraser directly on an intended location on a piece of paper, children using the word-processor must use directional arrow keys to indirectly navigate the cursor to desired locations on the electronic screen. In so doing, they are forced to consider directionality on an explicit and abstract level—a task which, in itself, requires a great deal of cognitive effort on the part of the young child.[5] (Developmental differences may have accounted for the fact that this was more of a problem for some children than for others.)

While a number of first graders were able to relocate the cursor to a particular delete or insert point, they often became confused when the text to the right of this point "moved" as text was inserted or deleted. A typical response to this automatic reformatting was to stare at the screen, then scan and/or reread the reformatted portion of text, presumably to make sure that it was still there (or that it was still the same). For a few children who were observed to edit their text more regularly than others, this initial disorientation in response to reformatting disappeared with practice. In general, children rarely found occasion to delete or insert in the middle of their text. This may have been a function of the difficult or confusing aspects of this task, or it may simply have been due to the fact that as novice writers, most first graders rarely found a need to edit their text (other than making immediate on-line corrections).

The automatic word wrap was readily adapted to by most children. However, a number of children developed their own idiosyncratic ways of advancing from one line of text to another. Some children pressed return, typewriter style, at the end of each line. They did this even after it was pointed out to them that words would wrap, intact, automatically. This preference may have been a function of aesthetics— i.e., they liked the look of the return marker (a bent arrow) which appeared on the screen whenever the return key was pressed in *Magic Slate*. However, this would not have been a factor for other children, who, when nearing the end of a line, would press the space bar until they advanced to the next line, then resume their writing. One explanation for both of these approaches is that these children were uncomfortable with the temporary appearance of there "not being enough room" for a word (letters must reach the very edge of the screen before the word advances). This would seem unlikely, however, when one considers the fact that children writing with paper and pencil often run out of space and write sideways or break words apart to compensate.

An interesting possibility is that the automatic relocation of text was somehow confusing or disorienting to young children. While the fluidity of electronic text lends itself to greater control on the part of the writer, functions such as automatic word-wrap and reformatting (in which text "moves on its own accord") might actually interfere with the young child's sense of personal control during writing. The notion that a written product remains essentially the same even when its location or format is altered may pose a conceptual challenge at this stage. We do not know the extent to which the physical stability of text is an important factor for young children as they engage in writing. Our observations indicate that this is an hypothesis worthy of further consideration.[6]

Children's responses to the scrolling of text (when text reaches the end of the screen) provide further evidence that the stability of text may have been an issue of importance to young writers. Not surprisingly, all children expressed initial surprise and concern the first time their first line of text "disappeared" as they advanced beyond a full screen of text. Most children accepted the technical assistant's explanation, while using the arrow key to scroll backwards and double-check for themselves that their text was indeed still there. During later observations, some children reassured themselves aloud every time their screen scrolled ("I know it's still there." "Its up there. It didn't go away.")

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[5] It would be interesting to compare children's use of the mouse, in which directionality is experienced kinesthetically (similar to a pencil in this regard), with their use of the arrow keys. There may be a trade-off here--while the mouse may be cognitively less complex, it requires more eye/hand coordination.

[6] Perhaps some of the characteristics of the preoperational stage of development (e.g., the inability to reverse operations) are relevant here. It would be interesting to examine whether more general developmental differences distinguished between those children who had difficulty with the automatic relocation of text and those who did not.

It was not unusual for children to write stories that extended beyond a single screen in length. When asked to reread these stories, some children became disoriented, and appeared to lose their place in the text when they reached the end of the screen and advanced to the next line. Once again, the automatic repositioning of text on screen (in this case, text "moved upwards") seemed to be a source of confusion. Several children found it necessary to scroll back to the first line of text, rereading their story from the beginning—only to become "stuck" again when they reached the bottom of the screen and scrolled downwards. It would be interesting to compare children's rereading from programs that advance line by line (as in *Magic Slate*) with their rereading from programs that advance screen by screen. The latter approach is more analogous to "turning a page," and does not involve the repositioning of previous text on the screen. While this approach may be found to better support rereading, it would probably not aid writing, however. When writing, children often referred to or reread the text that immediately preceded their current place in text. Under these circumstances, it would not serve the needs of the writer if the program were to advance to a blank screen (in which case previous text is "located" on the previous screen), rather than a blank line (in which case previous text is still displayed).

In the following section, we report on children's performance on the posttest to assess word-processing skills and continue our discussion regarding children's editing at the computer.

Posttest on Mastery of Word Processing Functions

At the end of the school year, first graders (22 total) were given a posttest to measure their mastery of *Magic Slate* functions (see Appendix.[7] This posttest differed from the pretest, as it was designed to allow for a more detailed analysis of children's word processing skills, given their additional exposure and experience.

In the test, each child was asked to: start a new paper, enter a title for the paper (his/her name), and type the sentence "I like cats." from a model (a computer print-out of the text). After confirming that the text matched the model, the child was given another model sentence ("I like my cat.) and was instructed to edit his/her text in the following manner: "Here is a new sentence. It says, 'I like my cat.' Fix your sentence so that it looks just like this one. You don't have to start over, just change the parts that are different." The purpose of this task was to look at the child's command of basic editing functions (e.g., using the arrow keys to relocate the cursor, deleting and inserting text), rather than to examine the child's ability to read or write conventional text. For this reason, the examiner attempted to scaffold the non-relevant aspects of the task, reading aloud while pointing, and then directly pointing to the places (on screen) in the sentence where text should be inserted or deleted. Descriptive notes were taken on the child's approach to editing. If the child deleted "cats" in order to insert "my," she was asked if there was another way to add text to the middle of a sentence, without deleting the last half of the sentence. After editing the model sentence, the child was asked if there was "anything else" that he/she would like to show the examiner. In the remainder of the posttest, the child was asked to save and print his/her text, and to load an old story. Each item on the posttest was given a numerical score (highest possible score equals 20), based upon the child's ability to perform the task independently, with some assistance, or with complete instruction only.

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[7] This number reflects the fact that two children left during the school year. Children who entered the classroom during the school year were not included.

As a group, first graders performed exceptionally well on the posttest. All but one child demonstrated sufficient mastery of the word-processing functions examined, scoring 17 or above on the posttest. There were a few areas, however, where a number of children became confused or required assistance. Some of these difficulties had to do with specific design features within *Magic Slate*, and have already been discussed (i.e., remembering to select "Edit" to display a file after it has been loaded; remembering which command to use—esc or Control-Q— in order to return to the Menu at different points in the program). The area of greatest performance variability was editing. Children's difficulties with editing on the word-processor have already been addressed. Our focus here is to describe their approach to the specific editing task presented in the posttest.

The editing task was a challenging one for many of the children. During the posttest, one child refused to edit, and several became very confused in their attempts. Many children (9) used an "undo and start over" editing strategy, deleting backwards from the end of text, and then retyping. That is, when asked to change the sentence "I like cats." to "I like my cat," these children deleted backwards (erasing "cats") and then typed "my cat." This strategy was used by several children who were later able to demonstrate that they knew how to reposition the cursor for more selective editing. These children had chose a less "advanced" approach to the editing task, perhaps because to undo and start over was a more straightforward approach, both procedurally and conceptually.

Ten children spontaneously attempted to reposition the cursor to selectively insert and delete text, with varying degrees of success. Few children were able to implement these procedures smoothly, while for most it was a hesitant and effortful process. Several children added extra spaces before inserting the word "my" (presumably "to make room" for the word, as they would have to do if writing with pencil and paper), and were then confused when they ended up with extra space after typing "my." Two children positioned the cursor to the left, rather than the right, of "s" and consequently deleted the wrong letter—a mistake which was corrected by both children. Several children had a great deal of difficulty repositioning the cursor, and in the process, seemed to lose their place in the text, as illustrated in the following descriptions.

> Uses arrow keys to relocate cursor first to the left, then to the right of the "c" in cats. Says, "I can erase it, then move it over." Inserts several spaces with the space bar, advancing "ats" to the next line. Looks confused and asks, "How do I get it back there?" With assistance, deletes the inserted spaces to reconnect "c" and "ats." Repositions cursor to the left of "cats" and types "like my." Repositions cursor to the right of "t" in "cats," deletes "t," then "a," then "c." Needs help repositioning cursor to the right of "s," deletes the "s." Types "cat."
>
> Uses arrow key to relocate cursor to the right of "t" in "cats." Deletes the "t," then notices she has deleted the wrong letter. Repositions cursor to the right of "s," deletes the "s," retypes the "t." Attempts to relocate cursor to insert "my" and becomes confused and frustrated. Deletes entire text up to "I," types "like my cat."

The above descriptions of children's attempts to edit reflect a transitional level of knowledge and skill. Rather than simply "undoing and starting over," these children were attempting a more advanced form of editing. They had not yet mastered the procedures, however, and consequently, their performance was more hesitant and error prone than those who took an easier approach to the task.

Summary Remarks

The issues we have raised in this section are complex and in need of further investigation. Given our observational approach, we are not in a position to say the extent to which children's difficulties were simply due to a lack of sufficient training or experience, or whether they were more conceptual and developmental in nature. Our speculation regarding the source of children's difficulties is exploratory and preliminary, raising questions for future research.

While our focus has been on providing a detailed account of the problems encountered, it should be noted that these difficulties did not prevent children from using the computer as a writing tool. For the most part, children learned to bypass the more complicated functions, and developed their own strategies for dealing with problematic features. By the end of the school year, they had mastered the basic procedures for writing at the computer. Editing remained the most difficult aspect of word-processing, although children were readily able to make "on-line" corrections and to alter their previous text by "undoing and starting over." Perhaps with continued practice and additional training, higher level editing procedures would become a part of the first grade writer's repertoire of word-processing skills (assuming they have a need for these procedures). This has important implications for the classroom, given limited instructional support and shared computer access.

Children's Conceptions Regarding Writing at the Computer

At the end of the school year children (22 total) were interviewed regarding: 1) their conceptions of how writing at the computer differs from writing with a pencil and paper, and 2) what happens to the text that is written at the computer. A description and rationale for this interview can be found in the kindergarten section of this paper. In the following paragraphs, first graders responses are summarized and discussed.

How Writing Gets Done

In the first part of the interview, children were given the example of writing with a pencil ("You take your pencil and make marks on the paper like this...), and were then asked to describe some of the differences between writing with a computer and writing with a pencil. About half of the children (10) focused upon the use of the keyboard for entering letters, versus forming the letters by hand, as the most salient difference between the two writing tools.

> On the computer, you have to press buttons. When you're using a pencil we have to write the letters and words.
>
> You press the key that you wanted to write, and then it will put the letter you pressed on the screen.
>
> And pencils don't write like computers. It doesn't just go like that (presses a key). You have to move your hand and make it. And you don't have to sharpen your computer.

In addition to mentioning the keyboard, several children talked about the procedures or functions associated with word processing, such as "save" and "load." These procedures were characterized in different ways: as part of a step-by-step description of the process of writing at the computer, as the notable features that make computer writing an "important" activity, and in terms of the extra effort they require:

> The keyboard is what you have to write with. And if you want to finish one or make a new one, you do "New," and you put a title. Then you press return, and you get a blank screen. And then you type the letters...like if you want to write kangaroo, you see where the line is and you write K-A-N-G until you get to kangaroo.
>
> The way a computer is different from writing on a piece of paper is you press the keys, and you do not press keys on paper. And you have to save, edit, lots of important things that you don't have to do on a piece of paper.
>
> Well writing at a computer you have to save and print and fiddle around with things. When you're writing with a pencil and paper, it really isn't that hard because you don't have to save. It's already saved and you have to just dart down your pencil to make a period (demonstrates), and you have to press a key when you want to have a period on the computer.

While most children focused upon the concrete and procedural differences between writing at the computer and writing with a pencil, some children addressed the more abstract issue of underlying process and control (the connection between the child's actions at the keyboard—i.e., pressing keys to enter text—and the written product). Several children indicated that they thought the keyboard communicated to or commanded the computer, instructing it what to do.

> Well, you use the keyboard to tell the computer—You don't talk to the paper. You talk to the computer with the key bars.
>
> Inside the computers there's this thing that has all the letters and the numbers, and when you press it, it goes onto the paper. (Is the paper inside of it?) No...Maybe the letters are in back of the screen, and they just come out.

The lack of a directly visible connection between pressing a letter key and seeing the letter displayed on the computer screen led to a certain amount of speculation on the part of some children. Several children hypothesized that the letters physically travel through the chord that connects the keyboard to the computer. In attempting to describe how the computer operates, some children referred to the "computer's brains," (although it was not always clear what function they were attributing to it). Perhaps the notion of a computer having brains is not so much a reflection of the child's theorizing as it is of socially transmitted information (a kind of cultural folklore about the computer). Not surprisingly, the issue of how a computer works was a confusing one for children, as it is for many adults.

> You press the keys...the computer has a little brain that tells it which letter...There's lights from the computer that light up the letter.
>
> Well, the computer has a brain. (Does a pencil have a brain?) No.

> Whichever key you press is what shows up on the screen... When you push all of these keys, the letter goes through the cord and up to the computer brains and it shows up on the computer screen.
>
> I thought it was magic. (...Can you describe the magic?) Just if you think about a letter, and you just typed it, and there's lots of letters in there, and it goes through there (points to cord) and goes in there (points to screen).

Saving Stories

In the second part of the interview, children were given examples of how stories written with pencil "get saved" (in writing folders) and were then asked to describe what happens to their stories written at the computer. Most of the first graders said that their stories were saved on a disk, or in the computer. They seemed to regard the text written at the computer as both permanent and retrievable. Although they were sometimes unsure as to its exact location, they insisted that, as long as they had saved it, they could get it back.

> It gets saved, then you can get it back, and then you can print it.
>
> Well you push save...and the thing inside saves it.
>
> The disk has all the stories then when you put it on load, all the stories go back on, then when you press return, they come back to the screen.

One child described text written at the computer both in terms of its indestructibility (it can't be tampered with easily) and its vulnerability (if you don't save it, it disappears).

> The computer prints letters that you can't touch inside. It's not all globby and it can't get destroyed. And on the paper you can (save) by just putting it somewhere. You have to press save here and if you don't it'll just go black.

Several children made an analogy between saving stories in a folder or on paper, and saving stories on a disk or in computer files.

> You save it on your disk when you're writing with the computer. You save it on paper when you're writing with paper.
>
> When I'm finished with a (pencil/paper) story, I just get out this folder. It's called a writing folder. It just saves all the writing. That's a safe place...Same with this disk. What you just saw a few minutes ago (referring to list of files) was a folder to keep all the stories in, to keep all the titles, instead of the stories. It kept the stories and the titles...Kind of the same but you don't have folders that you can see.

Four children used metacognitive language to describe how the computer saves a story (e.g., "it remembers..."). It is not clear whether these children were attributing intelligence and intentionality to the machine, or whether they used this language for lack of an adequate terminology. Once again, the notion of the "computer's brains" emerged, this time in terms of its role in the saving process.

> You save it...And then it remembers the story you wrote.

> You just get to save and it saves it in it's brain...Our disk has our stories in it...And it doesn't forget about them if it's been saved.
>
> You press save, it goes through the chord, and it goes up to the computers brains and saves.
>
> (How do you get your stories back...?) Put load. It travels. It goes in the brain and it knows what you're talking about. It goes to the names that you want...

Children's understanding of the reason for saving text at the computer was separately addressed during the posttest on mastery of word-processing procedures. After being instructed to save her text (with assistance provided as needed), each child was asked, "Why do you save?" As a group, the first graders responses were highly consistent. Seventeen children (out of 22) focused upon the fact that, if you don't save, you cannot get your story back because it is lost, erased, or thrown away.

> I don't want to lose my story, and if I don't save it, I wouldn't be able to print it. (You wouldn't be able to print it?) Cause then it wouldn't be in the computer anymore. (Where does it go when you save it?) Onto the disk.
>
> It keeps the story. If you don't save, it forgets the story and then you can't get your story back. You just have to make a new one.
>
> Because you don't want to erase your story. (What happens when you don't save?) It erases your story completely.
>
> So the writing doesn't go away. (What happens if you don't save?) When you push it up, it would be blank.
>
> If you don't save, you can't keep it. (Where does it go?) In the garbage.

Building on the same theme, five children said that you needed to save in order to work on your story another time, to finish it, or to print out another copy.

> If you want to add more on it. (What if it's not saved?) You can't have more on it because it would be erased.
>
> You might want to print them again.

One child stated that the need to finish an incomplete story was the only reason for saving it, otherwise a hard copy would suffice.

> Because, if you don't finish your story, you have to save it for the next time. If you finish it, you don't need to save, you can just print it.

Some children (4) emphasized the fact that not saving your story meant having to start over from scratch—an especially undesirable predicament if the story was lengthy.

> If you don't save, everything just erases...how about if you got to the highest page you ever got to and it got erased all and you had to start over?

> So that you don't lose your story. Cause if you want your story, you have to save it or else it's lost and you have to type it all over again. And if it's a really long story, you won't like that.
>
> If you haven't finished your story...(If you haven't finished it, why do you want to save it? Why don't you just sort of leave it there?) Cause it's a long story and you don't want to start over again or you're going to have to stop where you did last time. (What do you mean...what happens if you don't save?) Cause if it was a long story then you wouldn't want to start over a long story again.

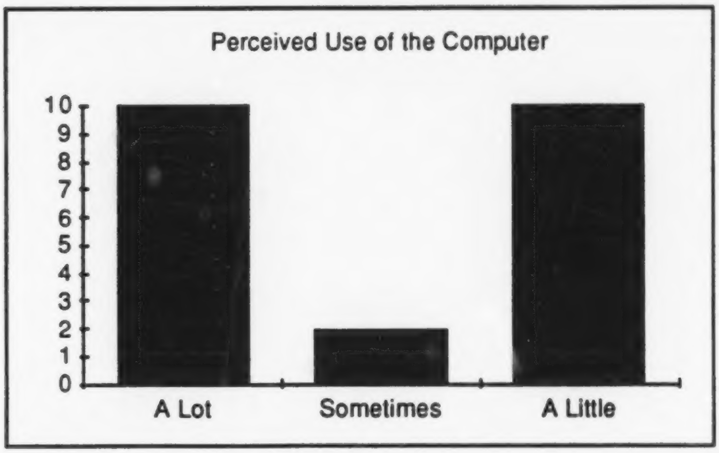
In summary, first graders conceptions regarding writing at the computer reflected a strong understanding of many of the physical characteristics, as well as the practical issues, associated with this activity. The abstract nature of computer writing, as compared to writing with pencil and paper, was a source of confusion and speculation for some children. A few children devised their own theories regarding the process that underlies a computer's functionality; while most others did not address this issue. All children seemed to regard their stories that were written at the computer as permanent and retrievable, with most noting that this was conditional upon the saving of text.

Children's Attitudes Toward Computer Writing

Most of the children in this classroom came to the first grade with previous computer experience. Judging from their initial comments and their eagerness to participate in the introductory sessions, all but a few children looked forward to the opportunity to use the computers again. Once the software training was completed, children's interest in writing at the computers was generally high, though it varied from child to child, and from week to week. Overall, first graders chose to use the computers more often than kindergartners (patterns of use ranged from once a month to twice a week for short periods of time). As with the kindergartners, many spontaneous positive comments were overheard as children worked in the computer area ("I like this!" "This is fun!"). By the end of the year the children became more selective. When the teacher went through the class list asking for volunteers to work at the computer many passed up the invitation. While it is not possible to ascertain the various motivatons for this, it appeared that some did so because they were working on special projects at their desks. For others it may have been in response to the teacher's frequent comments that the computer should be used for their best writing efforts.

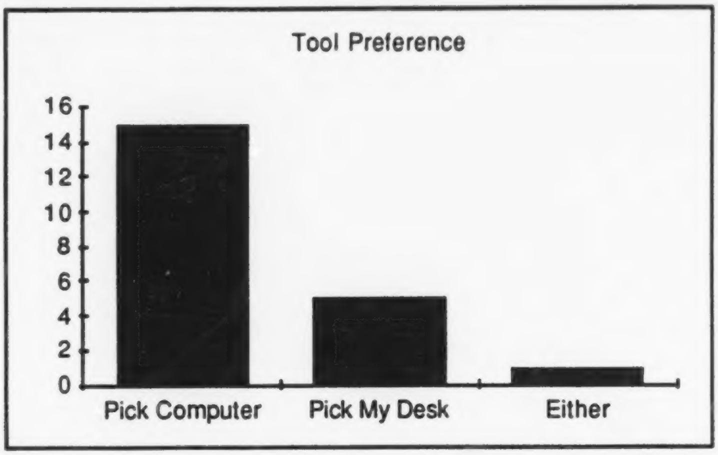
The social aspect of writing with computers was an important one in this classroom. Whether working at a single computer collaboratively, or side by side at separate computers in a parallel fashion, children took an active interest in one another's activities. Newly discovered functions (type styles, page insert) were shared with obvious delight. Children writing on their own frequently took time out to observe what others were doing, and/or to call attention to their own work. This mutual interest and opportunity for sharing was certainly a part of the appeal of the computer area.

At the end of the school year, children (22 total) were interviewed regarding their perceived amount of computer use, whether or not they chose to write stories at the computer, and what they liked best about writing both at computers and at their desks. The questions asked of first graders differed slightly from the kindergarten interview, reflecting the different approaches to how the computers were made available in the two classrooms. In the kindergarten classroom, computer use was completely unmonitored and self-selected. In the first grade classroom, the teacher used a class list to monitor turn-taking at the computers, beginning each writing session by asking individual children who did not have a recent turn if they would like to write at the computer that day. In the posttest interview, first graders were asked, "When [the teacher] asks if you want to write a story at your desk or at the computer, which do you usually pick? Why?"



In terms of overall computer use, ten children said that they used computers "a lot," ten said that they used them "a little," and two said that they used computers "sometimes." When asked what they used the computer for, twenty-one children named writing, with some children elaborating on writing for different purposes (class books, letters to kids, making stories, making invitations, writing some words). In contrast to the kindergarten, typing was not mentioned as a use by anyone, although one child said that she liked to "press a letter and wait 'til it goes through a whole line." Six children said that they used the computers for learning about or working on numbers (an activity that usually took place in the afternoon, and sometimes during writing sessions, although it was generally discouraged). One child mentioned spelling, and another child said that computers were used for "listening to words" (this could have been based on his Writing to Read experience, or his exposure to the *Reading Comprehension* program). Two children said that they used computers for drawing, and three talked about playing games on the computer. These latter uses were referring to experiences with computers outside of the classroom.

All but two children said that they liked to write stories (these two children said that they preferred to write at their desks). In response to being asked whether, when given the choice, they wrote at computers or at their desks, fifteen children said that they chose computers, five said they wrote at their desks, and one said "either." One child gave a conditional answer, stating that she chose to work at computers "only if I have an important story or only if I want to share a story." This view that computers were a limited resource to be reserved for special purposes was reflected in other comments as well. For example, one child said that he usually chose writing at his desk "'cause I don't want to waste my turn... We have special days when you can only work on it (the computer) once." Another child said that the thing she liked best about writing at her desk was that she didn't have to "waste [her] turn" at the computer. Overall, children's perceptions of computer use were very positive, with most children claiming that they chose (at least sometimes) to write at computers when given the opportunity to do so.



When asked what they liked best about writing at the computer, children's responses varied from the very general ("Because I like it." "Everything." "It's fun.") to the very specific. Only a few children mentioned characteristics that were descriptive of writing in general ("You can write stories."). Most of the children focused upon features or functions specifically associated with the computer (the keyboard), or the software (*Magic Slate* menu choices). Efficiency and aesthetics emerged as two dominant themes, with many children stating that they could work faster or edit more easily at the computer, or that their computer-written text looked more attractive than their hand-written products. The tediousness of forming letters by hand was frequently contrasted with the ease with which one is able to enter text at a keyboard.

> Cause the spelling is better and sometimes the story's kind of long and I have to go faster than my handwriting will or it doesn't look good. (Tell me about what you mean by your spelling is better at the computer.) ...When I write, I'm always in a hurry...Sometimes I make mistakes when I write. Each time, I press a button to erase. When you have a pencil, you have to turn it around and rub it when it has to come off.
>
> You write in a straight line, and you can put capitals and noncapitals. (Can you do that at your desk too?) Yeah, but I like it when you can change easily, and if you do that at your desk, it's more time.
>
> I can do real letters...You don't have to make letters.
>
> What I like best is the part of touching the keys and writing.
>
> Not having to keep putting periods and writing the letters.
>
> You can just type with not taking a pencil and writing one word, and then another, and my hand gets all tired out.
>
> It can change the shapes (referring to type styles). It can get to a second page easier. You don't have to go all the way over and get it.

> On the computer, I can style it different ways, like "Shadow," "Outline," "Stencil." And it erases a lot better. When I erase with a pencil, it leaves a mark.

The notion that one has a range of options to choose from at the computer was highlighted by several children. While pencil and paper certainly offer a great deal of open-ended flexibility, the computer offers a different sort of opportunity for excercising one's options. For one thing, many of the choices that are available at the computer are made explicit by the software. Each of the menu choices, for example, has a label associated with it, as well as a specific procedure for implementing that choice. While many of these choices in themselves are not unique to the computer (working on an old story, editing), their level of explicitness may contribute to children's awareness, and consequent listing, of the options in this context. This ties into the notion that the computer requires a more abstract level of interaction between the writer and the written product, resulting in a more formal knowledge of the processes involved.

> You can have stories that are long or short. And you can decide which do you want to do—work on one of your old stories or work on a new one. Or you could print the same old one and copy the old one with paper and pencil and write a picture. That's what I like doing.
>
> You can do lots of things—print it, load it, edit it, save it, write it. You can make new stories any time you want, and you can save them. And you can if you don't like the story, you can quit or delete it.

A few children addressed the social aspects of writing at computers, mentioning the opportunity to work with their peers as a benefit associated with this activity.

> Because I saved things I wrote with my partner... Cause we don't finish it.
>
> Because I usually pick other people to help me and someone can tell me what to write. Or I can tell the other person what to write. And it'll be a lot baster and better...

Many children expressed, both directly and indirectly, the idea that writing with computers was somehow "more special" than writing with papers and pencils. The fact that the computers were a more limited resource than pencil/paper certainly contributed to this perception. Perhaps the notion that computers are more technologically advanced and sophisticated (and therefore more adult-like) also played a role. As one child put it, "Because on your desk, it's sort of boring just writing on paper."

When asked what they liked best about writing with paper and pencil, many children mentioned the fact that they could draw pictures, write any way they wanted, or that they could use their crayons, markers, and different kinds of paper.

> You can put pictures in when you write at your desk.
>
> I get to use my new crayons and I get to use my new pencils too.
>
> You can waste up the ink in your markers... I have all the colors that I hate.

> At your desk, you can illustrate better. The computer doesn't illustrate at all.
>
> There's no color on the computer... We get to pick our own selves what kind of paper we want—with all lines, and I usually pick all lines.
>
> I can write anything that I want.

Several children noted that, when writing with a pencil in contrast to the computer, they did not have to locate letters on the keyboard.

> There's more space and it's easier to find the letters!
>
> Not looking for words, just writing them.

For one child who had used the computer a great deal initially, the pencil became a preferred writing tool when his focus shifted to improving his handwriting skills. He described his tool of choice as, "a little more pencil because it helps me learn lots more to write letters."

Another child talked about her preference for writing at her desk in terms of the need to finish papers in progress. This was another example (along with not wanting to waste one's turn) of how the pragmatic issue of "computers as a limited classroom resource" impacts upon children's decision-making and attitudes towards computer use. Regardless of their initial preferences, children write with a pencil much more often than with a computer, and this in turn influences their continued preferences.

> I do it at my desk because I have a lot of things in my writing folder that I have to finish...You can't just make a new story [on the computer] when you have lots of stories to finish.

In general, children's responses regarding writing with paper and pencil were much less elaborate than their responses regarding computer writing. This may have been due to the interview itself, which initially oriented children towards thinking about their use of computers in general. In addition, the fifteen children who said they elected to write with computers when given the choice were requested to explain their preference further (as opposed to the five children who said they usually chose pencil/paper).

It was clear by the end of the year that the majority of the first graders thought of the computer as a writing tool, and chose to use it as the occasion dictated. Many of the children were able to identify what they saw as the advantages associated with both writing with the computer and writing with pencil and paper. Each had distinct advantages, contributing to the notion that the computer had become an attractive literacy tool for these children that facilitated writing in many ways.

SUMMARY OF THE PILOT YEAR

Many questions guided the research on the use of computers for literacy development with kindergartners and first graders. Many of them will not be fully answered for several years as the second phase of the project begins in September, 1989, in a large urban school district. But a number of tentative conclusions can be reached from the pilot year. These conclusions are based on a year-long test of the use of the computer as a writing tool, but in a unique and limited setting—one classroom each at the kindergarten and first grade level in a single school. Although among the 47 students there was considerable diversity in family background and individual ability, these pilot students are not representative of the full diversity of students in American schools. The participating teachers were exceptional, selected because of their extensive experience as well as their interest in collaborating with the CIEL project. The presence of three computers in their classrooms was a novel, but exciting prospect for them. The classrooms themselves were "literacy rich," offering a wide range of materials and activities to support reading and writing in ways which were consonant with an emergent literacy approach. In short, this was an unusually supportive setting for the CIEL implementation—one which was appropriate for testing and refining instructional and research strategies. But the unique environment should be taken into account when considering the applicability of these findings to other settings.

Kindergarten

The kindergarten classroom was provided with three Apple IIGS computers equipped with the *Color Me* graphics processor and *Muppet Slate* word processor. The computers were installed in late November. At this time it was determined that two-thirds of the children had some prior exposure to computers, but little detailed knowledge of them. Most children associated computers with playing games rather than with writing.

Software training consisted of individual sessions with an adult at the computer. Once students were trained, students could use the computers on a self-selected basis at various periods throughout the day. Initially, almost all students were interested in having a turn at the computer. But with time, given freedom of choice, about one-third of the students maintained a high level of interest, using the computer several times a week; most used it on occasion (4-8 times total) and the remainder used it very little, if at all. Children's mastery of the software (as measured by the posttest) tended to correspond with their patterns of use, with high users mastering most or all of the basic word-processing functions and low users requiring a great deal of assistance, even at the end of the school year.

Color Me was quickly mastered and students had little difficulty accessing the menu, recognizing icons for functional choices, drawing with the mouse, entering letter strings, and printing out the results of their work. They had more difficulty with (and perhaps less of a need for) "saving" their work (electronically) and "loading" previously done work. Mastery of *Muppet Slate* was gradual. Kindergartners had little difficulty learning to make menu selections, typing letters (using either the Muppet Keyboard or the standard keyboard), and printing out their work. As with the graphics program, they had greater difficulty with the "save" and "load" functions. However, most of kindergartners who used *Muppet Slate* regularly became proficient with these functions. Others were able to demonstrate their ability to save and load by the end of the school year, following additional group instruction on these functions. Sophisticated editing functions were rarely used. While children were able to change or correct their text as they were composing (deleting and replacing letters), they were not observed to use higher level editing procedures to alter previously written text.

A variety of patterns of use and forms of writing emerged at the computers. All of the emergent forms of writing were observed to occur, however letter-based forms of writing seemed to be better supported, given the software provided. *Color Me* was used primarily for drawing pictures and making designs. Children were especially attracted to the graphics features of this program and did not tend to view it as a writing tool, although they did use it to enact stories, and to produce illustrations for pencil written stories on occasion. At *Muppet Slate*, children produced random and patterned letter strings, copied from environmental print, made lists of familiar conventionally spelled words, and engaged in invented spelling. Sometimes they composed stories, using any one or more of these forms of writing; sometimes they "played typist," using both hands to press keys rapidly as they watched the letters spill out onto the screen. In all cases, children took visible pleasure in their computer activity; two important aspects seemed to be their increasing sense of personal control when using the software/hardware, and their developing sense of themselves as writers (in this context).

Writing patterns at the computer were very similar to writing patterns observed in previous research with paper and pencil, with a few notable exceptions. Children who typically wrote with drawing or scribble at their desks usually wrote with random letter strings at *Muppet Slate* (which did not allow non-letter forms of writing). Random letter strings were of two types, which differed from one another both qualitatively and quantitatively. The first type involved a more selective use of the keyboard, with the child deliberately entering letters, sometimes naming them as they were typed or acting out isolated components of the writing process (e.g., "sounding out") without reference to a higher level compositional goal. The second type was characterized as "playing typist." This approach often resulted in a large quantity of text, which was the source of personal pride and attracted the attention of peers. Patterned letter strings seemed to correspond to the layout of the keyboard and typing patterns, rather than reflecting the deliberate ordering of letters, as in patterned letter strings produced with a pencil. All children who wrote with invented spelling (and who chose to write at the computer) were observed to write with invented spelling using *Muppet Slate*. These children often sounded out word segments aloud, as they did when writing with paper and pencil. They seemed to revise their invented spellings more often at the computer, however. While the ease with which they were able to delete and replace a letter at the keyboard may have contributed to an increase in editing at this level, the ease with which they were able to type the letter in the first place may have contributed to a greater number of initial errors. It is not clear whether the computer was enabling children to attend more carefully to letter-sound relationships by eliminating the need to attend to other aspects of the writing process (such as hand-writing).

In general, children writing at the computer appeared to pronounce letter names more often than when composing hand-written text. This seemed to be a function of their need to locate and to type keys on the keyboard—children would name the letter while searching for and/or while pressing the appropriate key—perhaps as a mnemonic strategy or perhaps as a way to maintain a connection between their actions (i.e., entering a letter) and the corresponding, though somewhat indirect, computer results (i.e., the letter appearing on screen). Children writing with invented or conventional spelling often paused to reread their text as they composed at the computer, more frequently than when writing with pencil. In addition to the compositional purpose that rereading generally serves, this activity at the computer seemed to aid children in locating their place physically in text. Regardless of the reason for its occurrence, more frequent rereading may have been a contributing factor in the tendency to revise more often at the computer.

Some of the features and functions associated with *Muppet Slate* drew children's attention to particular aspects of writing, such as spacing and capitalization. Children were especially interested in the space key and the upper/lower case key on the Muppet keyboard—using the space key with overt deliberateness to separate words (by children who were already spacing words apart) or to arrange text on screen, and using the case key to explore "big" and "small" letters. We do not know whether these function keys contributed to a more conventional level of understanding. However, a by-product of children's frequent use of these keys was further exposure to the notion that text can be separated by spaces and an opportunity to see each letter in its upper and lower case form. An important aspect of the use of these keys, from the child's perspective, seemed to be the exercise of control at the keyboard (making "things happen" with the selective press of a key).

At least two children exhibited a higher level of writing on the computer than they had previously demonstrated with paper and pencil. While we do not regard the computer as a unique tool for advancing children from one stage of writing to the next, it seems that it was a particularly appealing or motivating tool for writing for some children. (Other children, it should be noted, looked upon the computer with little, if any, interest.) Based upon our observations of and interviews with children, we know that a number of characteristics associated with computer writing were regarded positively by the kindergartners. Many children were impressed with the ease with which they could enter and delete text at the computer. The elimination of the need to form letters by hand may have been a more salient factor for some children than for others. While the need to locate letters on the keyboard certainly counteracted this benefit, most kindergartners approached this task in a positive manner. Perhaps the notion that typing text on a computer keyboard was a "grown-up" activity added an aura of importance to this task. Another dimension of the computer's appeal can be described in terms of aesthetics. Children seemed attracted to the display of text on screen (surrounded by a colorful border); they were delighted with the quality of print, they enjoyed inserting pictures from the *Muppet Slate* picture book and selecting borders for the printed version of their work. We need to know more about how each of these factors—ease of entering and altering text, role-play, aesthetics, as well as the previously mentioned exercise of control at the keyboard—plays a role in children's interest in and use of the computer as a writing tool.

One of the most popular features within *Muppet Slate* was the Picture Book, which allowed children to select and insert ready-made pictures into their stories. These pictures were used in a variety of ways by children—as decorations on a page, as illustrations to a story, and as part of the compositional process (to generate and extend story ideas). Some children used their knowledge of letter-sound relationships to locate particular pictures (pressing the letter 'c' to access a picture of a cat). Some children included pictures in the story rereading process, pointing to pictures as they told or "read" segments of the story. The Picture Book feature is not commonly associated with word-processors, but it seemed to be a worthwhile option, serving different purposes for different children.

Other special features within the software are worth noting: The use of icons, both in the menu and help sequences within the program, and on the Muppet Keys for function keys, was a design feature which aided children's use of *Muppet Slate*. Children who were not yet reading conventionally quickly learned to make menu choices and to access on screen help when needed. The alphabetic arrangement and the depiction of both upper/lower case on letter keys were two features of the *Muppet Keys* touch pad keyboard that seemed to facilitate the entry of text. However, the keys themselves were difficult to manipulate. Many children alternated between the standard keyboard and the *Muppet Keys*, using the former for text entry and the latter for difficult to locate letter keys or alphabet activities. A general observation in our work with children and computers has been that, when faced with an obstacle or developmental mismatch within the software/hardware, children will often develop their own strategies or adaptations to meet their needs.

Collaboration occurred at the computers, usually in the context of one child getting drawn into another child's computer activity as he was waiting for his turn at the computer or was passing by the computer area, in route to another activity. True collaboration, in which both children took part in every aspect of the story writing process (planning, deciding on text, breaking down and entering text, rereading text) was rare, although it was observed to happen on several occasions. More often, one child would serve as an audience and/or as a technical assistant to a designated writer. These roles served important purposes, aiding the writer in developing a sense of audience, and freeing the writer to attend to more global aspects of composition.

Children's conceptions regarding how writing at the computer differs from writing with pencil, and regarding what happens to stories once they are written at the computer were briefly explored in an informal interview. A number of themes repeatedly emerged: the physical aspects of writing at the keyboard (pushing buttons as opposed to maneuvering a pencil); the automaticity of entering/deleting text; the notion that, when saved, your story is located somewhere (on a disk, in the computer) and is retrievable. By the end of the year most students in the class conceived of the computer as a tool for writing.

The kindergarten teacher's notion of the computer as a literacy tool within her classroom evolved during the school year. She took an increasingly active role in demonstrating its use as a writing tool, and in incorporating it into the classroom. Her sense of ownership with regard to these machines seemed to change, such that by the end of the year she was instituting new procedures for computer use and providing her own group instruction on these procedures for the class. Whereas she was hesitant to introduce computers early in the first year of the CIEL project, she was anxious to use them as soon as possible in the following school year.

First Grade

The first grade classroom was also provided with three Apple IIGS computers. They were each equipped with a *Magic Slate* word processor. Many of the first graders in the pilot year were familiar with and even experienced computer users. Many had computers at home and more than half had been in the Writing to Read program in kindergarten—a program which uses the computer both for tutorial purposes and for composing stories.

Initial training occurred in late October and regular use of the computer began almost immediately. Initially, the teacher chose to have the students use the computers for publishing—creating a finished product after an initial composition had been completed in pencil. Within a few weeks, however, students used the computer at regular writing time for all phases of writing from composing to final editing.

With a short, but systematic, introduction to *Magic Slate*, 40 percent of the first graders were able to perform the basic functions of word processing, including creating a new file and entering text. With practice, the rest of the students acquired the basic skills. However, it took extended practice to master such functions as saving, loading, and editing—especially higher level editing that entailed relocating the cursor to selectively delete or insert text. Either the technical assistant or the classroom observer were available for individual assistance almost every day for the first few weeks, and on a weekly basis for several weeks thereafter. The assistance of these adults was critical, pointing to the high level of support that is required to add this amount of technology to the classroom.

Students provided some of the needed technical support. Many children chose to work in pairs at the computers, and in the process provided one another with technical support and assistance. Several of the children who mastered *Magic Slate* early became resident experts, called upon for assistance when needed. But any student could be a resource. Whenever one child "discovered" a new function (e.g., insert page break, change type styles), the news spread quickly. This level of support, coupled with the fact that children made regular visits to the computer, resulted in the first graders mastering most of the word processing functions by the end of the school year.

A number of aspects of writing with a word processor presented problems for the students. Some of these had to do with specific characteristics of the word processor used in this project. For example, the two modes of entry—typeover and insert—were somewhat confusing. The fact that editing a previously-written text required two steps—loading the file and then selecting edit was another problem, as were the text-based commands for formatting and printing the completed text.

Other difficulties were not product-specific, but rather inherent in processing texts in the fluid form that characterizes electronic text. Children were often uncomfortable with text moving on the screen—when a word "jumped" to the next line because of the word-wrap feature of word processors, or when whole lines of text disappeared from view after the user entered more text than would fit on a screen. Another challenge for first graders was the cursor. In the act of editing it had to be moved to a point where a deletion or insertion was desired. Part of the challenge lay in simply moving the cursor to the desired location using the arrow keys; the other part lay in remembering how to execute the desired action.

From the beginning of the year writing time was a daily feature of this classroom. For the entire second semester children were given the option to do their writing either at the computer or at their desks with a pencil. The patterns of self-selected use varied widely. Heavy users selected the computer 10-16 times over the course of four months; light users six times. A turn typically lasted 20-30 minutes. Children chose to use the computer in spurts; they would select it 2-3 times during a two week period while working on a single product and then not again for several weeks. By the end of the year many children routinely chose pencil writing when asked if they wanted to take a turn at the computer, selecting the computer only when its use fit particular social needs (the desire to work with a particular student), functional needs (the desire to make lists of words or numbers similar to others that had been done on the computer), or perhaps even whim. By the end of the year the computer with word processor was seen as another tool similar to the pencil and crayon to be selected when appropriate.

What children did when they used the computer varied greatly, depending on the child's mood and personal goals, the child's partner (if the child had selected a partner), and the task given by the teacher. In general, students in this class were encouraged by the teacher to write at a high level, especially when working at the computer. In some cases children wrote extended stories, longer than the teacher had seen children do with a pencil. More typically, they wrote short stories, ranging from one or two sentences to a page in length. In the course of writing their stories, children often stopped to reread the text from the screen. While many children altered their text to change the story or to correct spelling and grammar as they wrote, they were rarely observed to go back and edit previous text. In several cases the length of the composition and the adjustment of story and grammar elements seemed to be the direct result of two students working together, scaffolding for each other. Children were usually anxious to print out their products and to have an opportunity to share them with their peers at sharing time that occurred regularly after writing time.

In addition to story composition, other writing activities at the computer included making word lists (based upon particular themes); copying environmental print from around the room, and copying text from a book. Sometimes children played at the computer—perhaps pretending to be a typist. Other times they entered strings of numbers, letters or symbols with no apparent intent beyond seeing what was possible and pleasing to the eye. While some of the variation in production activity might be attributed to a child's literacy level, individual children varied from turn to turn across the full range of activities—one time working on a lengthy story, another time typing lists of words. But in almost every case children were doing what could be argued was literate activity appropriate to their level of development, or exploratory activity helpful in becoming familiar with the computer.

Early in the year the teacher trained the students in the skills of effective collaboration, teaching them to take turns and to be careful listeners and gentle critics. It was common for for her to have students work collaboratively at many academic tasks, but she did not routinely encourage collaboration during the prewriting or composing stage of writing. However, given the limited number of computers she decided to provide the option for children to use this resource in teams of two, even at the early stages of the writing process.

The collaborative activity appeared to be a useful educational process for both members of the pair. It entailed discussing oral stories and deciding on the most compelling story lines. The stories had to be translated to print, and in the process there was usually a discussion of many of the choices associated with the translation, ranging from which word to use and how it should be spelled. The shared text on the screen was continually re-read, and this provided practice in reading.

The roles played by the members of the pair varied. In some pairs there was true co-authoring, with relatively equal contributions of story line, word production, and technical expertise. In other pairs one student provided the story line while the other entered the text or served as the critic. In some pairs there was only a parallel activity, with students taking turns entering two different stories. While the roles varied from one pairing to the next, there were almost always opportunities for each member to scaffold the other in one aspect or other of the writing process.

These children liked using the computer. Initially they were very enthusiastic, always anxious for a turn. This initial response became more tempered as the year went on and there were more opportunities to use it. By April many children passed up a turn on the computer in favor of writing at their desk, but not in the sense of growing tired of the computer and rejecting it. Indeed, in the posttest conducted in June they were asked how they typically responded when the teacher asked them where they wanted to write a story—at their desk or the computer. Fully 20 of them said they liked to write stories at the computer, and 15 of them said they chose the computer over writing at their desk. Their reasons were very interesting. They cited efficiency (it's easier to form letters and to change the text when a mistake was made) and aesthetics (their paper looked prettier).

Lessons From the Pilot Year

One of the goals of the pilot year was to assess the adequacy of a rich and diverse set of research strategies. These included ethnographic observation, systematic collection of children's written products, and systematic student assessments. While very time intensive, these different approaches provided a rich set of insights about the process and effects of computer use in the classroom. Modifications for future research rest not on data collection strategies, but on design modifications to permit the study of different phenomena (e.g. more systematic observations of children writing at both their desk and at the computer).

In the pilot year three computers were placed in each classroom. This seemed to be a sufficient number to provide all of the students with a regular opportunity to use a computer. Their location in the classroom (as opposed to a central computer lab) was key to their being used on a regular basis. In general, we observed children using both the graphics and word processors with little difficulty. Their operation presented some challenges, but insufficient to deter children from using them.

For a five or six year-old to become proficient at graphics and word processing requires considerable time for practice and discovery in an environment that has the support of experts, both adults and peers. In a busy classroom with a number of competing activities training in computer use is best done by an adult other than the teacher. Assistance is also needed beyond introductory training. While some of this can be provided by student "experts," there is a clear need for the regular presence of an adult assistant who is very familiar with the operation of the computer programs. In addition, the machinery requires adjustments that demand adult assistance. Each station is comprised of many elements: monitor, cpu, keyboard, mouse, disk drives, printer and paper, and a great deal of cabling. Compared to a small collection of pencils and paper, the electronic tablet of 1989 requires a great deal of attention and care to keep it operating smoothly. For young children, a number of design changes could make the graphics/word processors and the computer hardware easier to use. The ideal electronic writing tool for kindergarten-first grade has yet to be made. But given the many positive things that occurred at the computers from a literacy perspective, the use of graphics and word processors seems quite worthwhile. Issues of cost and the management of support services must be weighed against these benefits.

The experience of these two teachers suggest that adoption and adaptation of computers to meet the needs of an existing literacy program is a gradual process, especially when computers are being integrated into a self-contained classroom instead of being available in a separate lab. These teachers needed most of the year to appreciate the pedagogical role of the computer and develop management strategies suited to this new and complex activity area. At the beginning of the pilot year they were presented with a wide array of software which they could use for writing and reading. Each chose the minimum; the kindergarten teacher chose both a graphics processor and word processor and the first grade teacher just a word processor. They rejected the offer of a reading comprehension program and several targeted tutorials. In part this represented where they wanted to start. But several times during the year they were presented with opportunities to add more software, and they declined. They felt their needs were being met with the existing tools coupled with work sheets and other activities. As they began school the next fall both were very enthused about having the computers in their classroom. They expressed the conviction that they were now very comfortable with the computers' presence and confident about how to integrate them into the daily routine. Perhaps this year they will consider the potential of other software.

The research conducted so far has answered a number of questions, but it has left others unanswered and in need of further research. Of greatest importance are questions surrounding children's perception of handwritten vs. electronic text. Does the fluid text on the computer screen present problems for some students as they seek to acquire a sense of the meaning of text? How does the child's notion of the "stability of text" impact upon the writing process? Does forming letters with a pencil have a different value than selecting pre-formed letters on a keyboard? Does the ease of generating electronic text lead children to engage in the writing act longer and in ways that lead to "better" writing? Are children more likely to revise electronic text to meet particular rhetorical needs than they are writing with paper and pencil? Do different levels of emergent writing (e.g., random letter strings) take different forms, or serve different purposes, when writing with the computer versus writing with pencil and paper? These questions call for a more systematic comparison between children's approach to and understanding of the writing process at the computer and with pencil and paper.

A full explorations of these issues is, in some ways, contingent upon the creation of software that is more ideally suited to the developmental needs of emergent readers and writers. Comparisons between computer writing and paper-and-pencil writing are limited in the sense that currently available software does not fully support all of the forms of emergent writing; that is, it does not allow children to go easily back and forth between drawing, scribble, and letter-based forms of writing (with the added support of basic word-processing functions). In addition, some of the features and functions of current word-processors are difficult for young children to understand and/or to use. As more developmentally appropriate software becomes available, we will be in a better position to judge the effectiveness of the computer as a writing tool for young children.

Still other questions revolve around the different contexts for writing in the two media. In these classrooms writing at the computer was frequently a collaborative activity. What are the particular contributions to literacy development of children negotiating with one another? To the extent that the many elements of collaborative work are judged beneficial, what role does the computer play in facilitating collaboration? Can collaboration be implemented as easily in a paper-and-pencil environment? To understand the most appropriate uses of technology in the development of writing calls for extension of the research efforts only just begun in the pilot year.

APPENDICES

(Bound Separately)

1. Observation Handbook
2. CIEL Posttest Instrument: Children's Attitudes, Procedural and Conceptual Knowledge Regarding Word Processing
3. Technical Log
4. Computer Pretest Methods and Results: Young Children's Prior Knowledge and the Acquisition of Word Processing Skills
5. Software Selection
6. The Software Finder: Early Literacy K-2 (print)